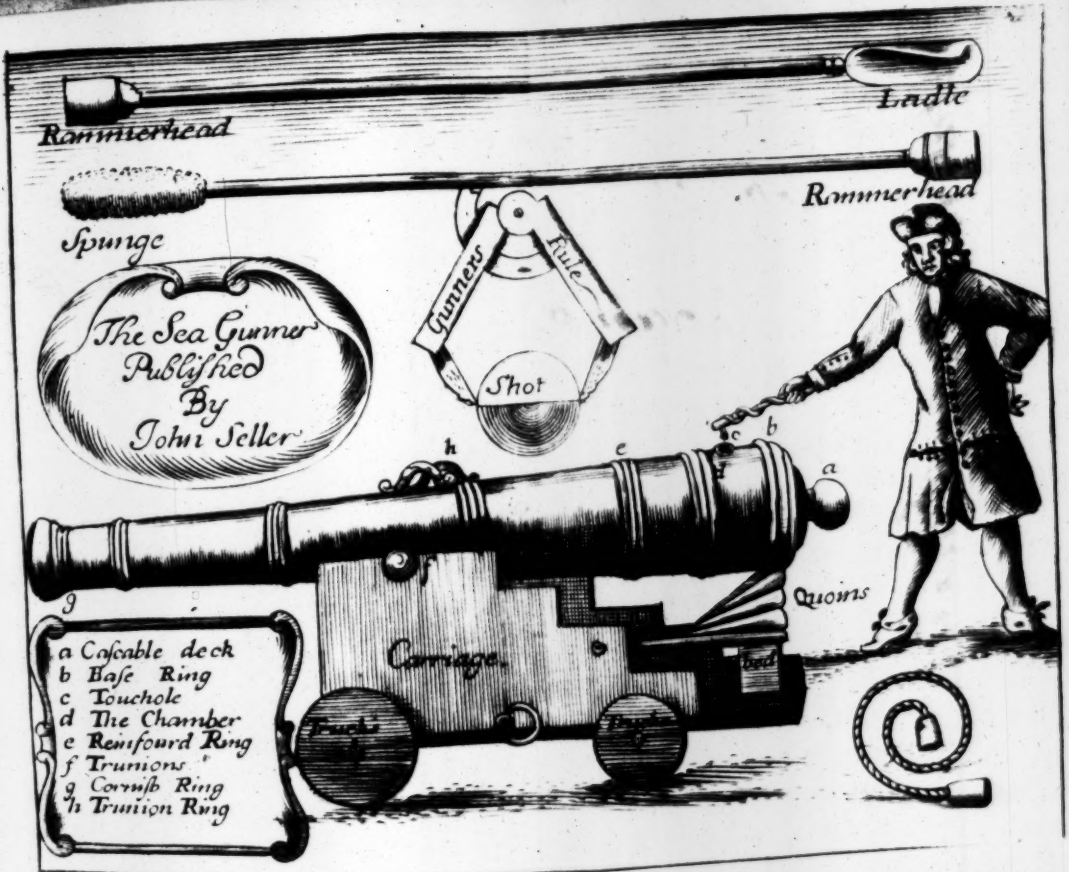
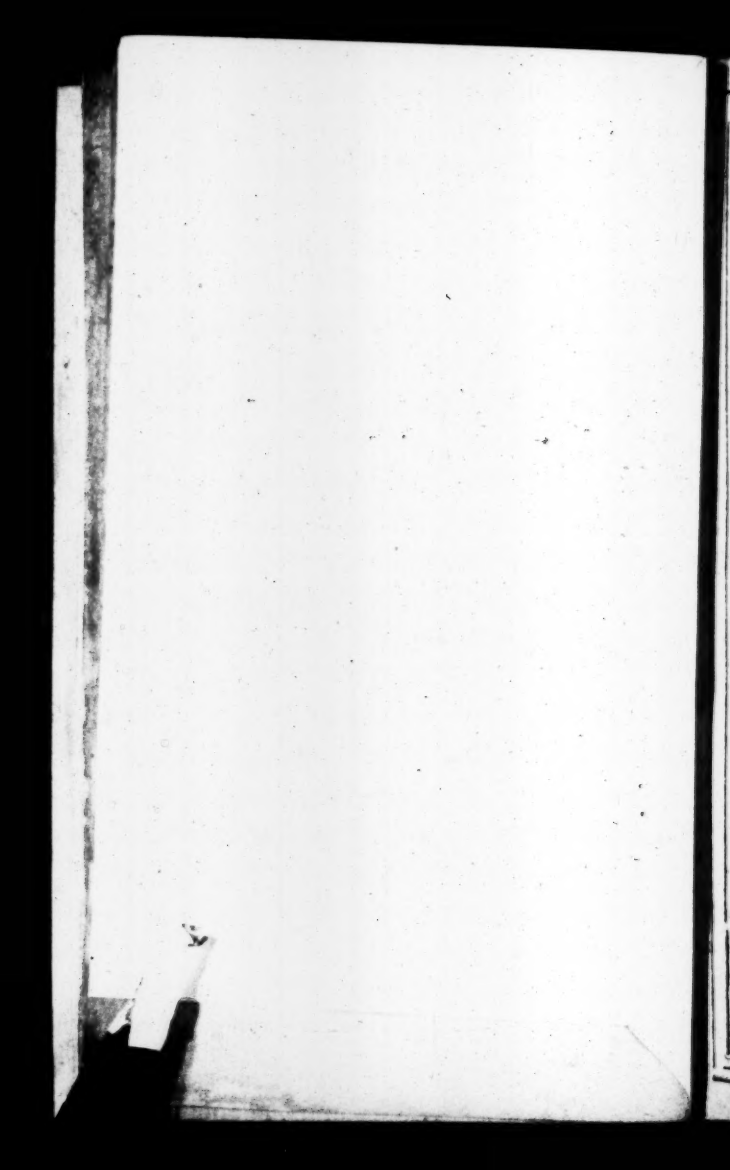


him at the *Hermitage* in *Wapp*



THE

Sea-Gunner:

Shewing the

PRACTICAL PART OF GUNNERY,

As it is used at SEA.

AND,

As an Introduction thereto, there is Exhibited two Compendiums, one of Vulgar, the other of Decimal ARITHMETICK, With necessary Tables relating to that ART.

To which is added

An APPENDIX,

Shewing the Use of a Proportional Scale, for the ready working of any Question in Gunnery.

And the Use of the Sea-Gunners Rule, of an excellent Contrivance; containing an Epitome of the Art of Gunnery in it self.

Composed by [illegible] SBEEBR, Senior.

LONDON:
Printed by *H. Clark* for the Author, and are to sold by him at the *Hermitage* in *Wapping*, 1691.

THE PREFACE TO THE READER.

Courteous Reader,

HAving observed for several Years, that there hath been a great want of a Piece of Sea-Gunnery, that has been principally adapted for Sea-Service, in a Treatise by it self; (for those Books that were Extant, were chiefly intended for Land Service;) and at this time most of them being out of Print, I judg'd this a fit opportunity for the publishing this small Treatise, hoping it will be gratefully accepted by our Sea-Gunners.

And in regard that those who would be Students in that Art, ought (in some competent measure) to be acquainted with Arithmetick; for the sake of such, I have exhibited two Compendiums thereof, one in Vulgar, and the other in Decimal Arithmetick, as a necessary preparation for the working those Questions that are incident to that Art.

And for the eaſe of ſuch as are not fully acquainted therewith, I have furniſhed them with a Proportional Scale, whereby they may perform all the Operations that are uſeful in Gunnery; as alſo, to extract the Square and Cube-Roots, and how to perform the ſame by Logarithms, and by Gunter's-Scale.

To which I have added ſeveral neceſſary Tables uſeful in Gunnery, *with proper Queſtions and their Anſwers, and uſeful Obſervations and Inſtructions,*

And for the better accompliſhing the Deſign of this Book, I have conſulted with the beſt approved Authors, that have written on this Subject.

Alſo at the end of this Treatiſe, I have preſented you with a ſmall Tract as an Appendix, particularly of the uſe of the Proportional Scale; and of the uſe of a Rule of a new contrivance, fit for the Pocket, that hath upon it, an Epitome of the Practical part of Gunnery *in it ſelf, which I call the* Sea-Gunner's Rule: *All which I ſubmit to the favourable conſtruction of the Judicious,*

And reſt your Friend to ſerve you,

John Seller.

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Robert Thompsons Book.

THE

THE Sea-Gunner.

A COMPENDIUM OF Vulgar Arithmetick.

CHAP. I.

ARITHMETICK is the Science of Numbring, and Resolving all Questions of Numbers, Rational or Irrational.

Notation of Numbers.

1. Notation of Numbers, is the Description and Explication of any Number by Figures or Notes, whereof there are ten, and no more.

One two three four five six seven eight nine ten.
1 2 3 4 5 6 7 8 9 10

Notation of Numbers, consisteth of Names, Values, Degrees, or Places and Periods.

As 1. Numbers are named, *Unites*, *Thousands*, *Millions*, &c.

2. Their Values is reckoned from the Right-hand.

3. Their Degrees or Places, are ten-fold, &c.

4. Their Periods, are *Unites*, *Tens*, *Hundreds*, which are Illustrated in the following Table.

A Table of Notations.

Names	*Millions*	*Thousands*	*Unites.*
Value	CXI	CXI	CXI
Degrees or Places	987	654	321
Periods	3	2	1
Integers.	999	999	999
	888	888	888
	777	777	777
	666	666	666
	555	555	555
	444	444	444
	333	333	333
	222	222	222
	111	111	111

Rule

RULE.

Begin at the Right-hand and go backward, and ſay, 9 in the firſt place is 9. 9 in the the ſecond place is 90. 9 in the third place is 900. 9 in the fourth place, is 9000, Nine Thouſand; 9 in the fifth place, is 90000, Ninety Thouſand; and ſo on; obſerving the Names above, their Values, Places and Periods.

NUMERATION.

Numeration is the firſt part of Arithmetick, and ſerveth to expreſs the value of any Number given; The Integers of Numbers, are the nine Figures and the Cypher, and begin to number them at the Right-hand, to the Left, increaſing each Figure ten-times as before.

ADDITION.

Addition is the gathering of two, or more Numbers into one Sum, and hath two general Caſes.

CASE I. In Addition of Tens, Hundreds, Thouſands, *&c.*

RULE. Draw a line under the Numbers given, begin at the Right-hand, and firſt place; add up the Unites, carry the Tens to the next place, and ſet the remaining Works below; ſo do all along as you go backward, and in the laſt place, ſet down all that you have added, with that which you carry.

Example.

	Years
From the Creation of the World to Noah's *Flood,*	1656
From Noah's *Flood, to the giving of the Law,*	0875
From the Law, to the Birth of our Saviour,	1508
From the Birth of Chriſt, to the Year	1690
	5729

In Addition of Integers and Parts.

RULE. Draw a Line under the Numbers given, and begin as before, at the leaſt Denomination; add up right, and ſet the particular Sums of the ſeveral rows, under every one, (in their proper place) according to their reſpective value, whether it be in Number, Weight, or Meaſure.

Example.

There are ſeveral Men owe a Merchant ſeveral Sums of Money; it is required to know the Sum of thoſe Debts.

One

	l.	*s.*	*d.*
One Man owes,	230	17	02
Another owes,	110	16	04
Another,	074	10	09
Another,	979	08	11
The Total Debt is	1395	13	02

SUBTRACTION.

Subtraction is the taking a leſſer Number from a greater, or an Equal from an Equal.

What remains, is the Reſidue, or Exceſs, and hath two Caſes.

CASE I. In Subtraction of Tens, Hundreds, Thouſands, from Tens, Hundreds, Thouſands, *&c.*

RULE. Set the greater Number above the leſſer, and draw a line under them. Then begin at the Right-Hand, and take the leſſer from the greater, or Equals from Equals, and ſet the Difference or Reſidue, under every one, in their due place.

Example.

	l.
A Man oweth to a Merchant	9758
And he hath paid of that Debt,	3514
There Remains due,	6244

CASE II. When ſome of the inferiour Numbers are greater than the ſuperiour Numbers.

RULE. Set your Numbers in order as before; draw a line under them, and begin at the Right-hand; and according to the Numbers reſpective value, borrow one of the next to the Left-hand above, out of which Subtract, what remains add to the ſuperiour, and ſet their Sum under the line; then what you borrow, pay to the next Number on the Left-hand below, and ſo proceed throughout the work, according to this or the former Rule.

	l.	*s.*	*d.*
As from	529	13	4
Take	347	16	7
Reſts,	171	16	9

Proof. Add the two inferiours; their Sum is equal to the ſuperiour.

MULTI-

MULTIPLICATION.

Multiplication ſerveth to perform that at once which *Addition* doth at many times.

And to multiply readily, it is neceſſary that the enſuing Table ſhould be perfectly learned.

Pythagora's Table.

1	2	3	4	5	6	7	8	9
2	4	6	8	10	12	14	16	18
3	6	9	12	15	18	21	24	27
4	8	12	16	20	24	28	32	36
5	10	15	20	25	30	35	40	45
6	12	18	24	30	36	42	48	54
7	14	21	28	35	42	49	56	63
8	16	24	32	40	48	56	64	72
9	18	27	36	45	54	63	72	81

The Uſe of this Table is to muliply any Number in the outer Column to the left hand; by any Figure at the top, and in the common Angle of meeting, is the Anſwer to the Queſtion; as 7 times 9, you will find to be 63.

In *Multiplication*, Note, that the uppermoſt Number is always the Multiplicand, and the lower the Multiplier; and the Figures which remain when the Work is done, is called the Product.

Multiplication may be divided into ſix Caſes.

CASE I.

If the Multiplicand have divers Figures, and the Multiplier but one;

Rule.

Draw the Multiplier into the firſt Figure of the Multiplicand, and ſubſcribe the Units of the Product, but carry the Tens to the next place; then draw the Multiplier into the ſecond Figure of the Multiplicand, and add the Tens you carried to the Units of that Product, ſubſcribe the Units of their Sum, and carry the Tens to the third place; accordingly proceed to the end of the work. As, if 5436 is to be mutiplied by 6, according to the following Example.

5436, Multiplicand.
6, Multiplier.

32616, Product.

CASE

CASE II.

If the Multiplicand and the Multiplier have each of them more than one Figure;

Rule.

For the first Figure, do as before; and having drawn the second Figure of the Multiplier into the first Figure of the Multiplicand, set the Units of the Product under that second Figure of the Multiplier, and carry the Tens, setting all the rest of the Multiplication as by the former Rule; and this directeth, making so many particular Rows of Products as you Figures in your Multiplier; at last add them together for a total Product.

Example.

4532, Multiplicand.
32, Multiplier.

9064,	Particular
13596,	Products.
145024,	Total Product.

CASE

CASE III.

If Cyphers are in the Multiplicand and Multiplier, or either of them;

Rule.

Set down to the right hand of the firſt Product as many Cyphers as are in the Multiplicand and Multiplier, ſo that the firſt Unit of the Product of the firſt Multiplier may ſtand under the firſt Figure of the Multiplicand, and work the reſt according to the other Rule.

Example.

As, 3400
2100

340000
68

7140000

CASE IV.

If a Cypher or Cyphers be in the middle of the Multiplicand;

Rule.

Work according to the former Rules till you come to the Cyphers, then under the first o, subscribe the Tens you carried; but under the rest of the Cyphers set Cyphers, except under the last, where subscribe the Units remaining of the Product of the next Figure of the Multiplier drawn into the Multiplicand; the rest is according to the other Rules.

Example,

As 240004
365

1200020
14400024
7200012

865201460

CASE

CASE V.

If a Cypher or Cyphers be in the middle of the Multiplier;

Rule.

Multiply as before is taught, until you come to the Cyphers in the Multiplier, which subscribe in order before the particular product of the next Multipler, drawn into the Multiplicand; then set the Units of its Product under that Multiplier, and observe the other Rules for the rest.

As,

```
  34262
   4006
 -------
 205572
13278600
--------
137051572.
--------
```

CASE VI.

If Cyphers be both in the middle of the Multiplicand, and also in the Multiplier;

Rule.

When you come to the Cyphers in the Mul-

tiplicand, then under the first Cyphers place, set the Tens you carried (if any be) and after that, as many Cyphers as are in the Multiplier (no Figure intervening) then multiply into the next Figure of the Multiplicand, subscribe the Units of the Product, and carry the Tens in the same Row, and so do in every Row of the particular Products, according as this or some of the other Rules require.

Example.

```
  24200024
    305004
  --------
  96800096
 126000000
726000720
---------
73906872096
---------
```

You may abbreviate *Multiplication* by the help of *Subtraction*; especially when to be multiplied by 5, or 9; As,

CASE

CASE I.

To multiply any Number by 5.

Rule.

Subtract half the Number, and to it add a Cypher.

Example.

As, 45276 being to be multiplied
——— by 5, halve the Num-
Product 226380 ber, and add a Cy-
——— pher at the latter end,
and the Work is done.

CASE II.

To multiply any Number by 9.

Rule.

Add a Cypher to the Number given to be multiplied by 9, and ſubtract the firſt Number out of it, and the Remainer is the Product or Anſwer of the Queſtion.

Example.

Let the Number be 6789, to which add o Cypher, and the Number is thus, 67890;

out

out of which ſubtract the firſt Number, and the Remainder is 61101, the Product or Anſwer of the Queſtion.

DIVISION.

Diviſion ſerveth to divide any Number into as many parts as you pleaſe, and conſiſteth of three Numbers, the Diviſor, the Dividend, and the Quotient; for ſee how often the Diviſor is contained in the Dividend, ſo many Figures it produceth in the Quotient; or ſee how often 1 is contained in the Diviſor, ſo many times the Quotient is contained in the Dividend, which is all one.

If you were to divide 888 *pound amongſt* 4 *men, the Queſtion is, what each man muſt have?* Order your Work as in this Example.

Dividend
Deviſor, 4) 888 (222 Quotient.
8

08

08
8

0

The firſt demand is, how many times 4 can you have in 8? The anſwer is 2, which 2 place in the Quotient; then multiply the 2 in the Quotient by 4, (the Diviſor) and that makes 8; place 8, under the 8 on the left Figure of the Dividend, and draw a line under it, and ſubtract 8 from 8, and there remains 0. Then take down the next 8, and demand how many times the Diviſor is contained in the Dividend (8) which is 2 times; ſet that 2 in the Quotient, and multiply the Diviſor 4 by that 2, which makes 8; ſet that 8 under the ſecond Figure of the Dividend, and draw a line as before, and ſubtract it from the 8 in the Dividend, and there remains 0. Proceed in the ſame manner as you have done with the reſt, and you will find 222 in the Quotient, and 0 remains of the Work; ſo that you ſee, according to the former Propoſition, that 4 the Diviſor is contained in 888 (the Dividend) 222 times; and the Quotient is contained in the Dividend, as often as 1 is contained in the Diviſor, which is 4 times: So that it appears by the Work, that 888 Pounds being divided between 4 Men, there is 222 Pounds comes to each Mans ſhare.

If

If 28770 *Pounds is to be Divided amongst* 84 *Men*; *the Question is, what each man must have?*

Note that Men is the Divisor, Money the Dividend, and Quotient is the Answer.

```
84 ) 28770 ( 342 42/84
     252
     ----
      357
      336
      ---
       210
       168
       ---
        42
```

For the first work, say how many times 84 can you have in 28? which cannot be; therefore you must find the Divisor in 287, over which last figure always place a Prick, as in the Example: Then say how many times 8 (the first figure in the Divisor) is there in 28, the two first Figures in the Dividend, which is 3 times; which 3 place in the Quotient, and multiply the Quotient by the Divisor, and it makes 252; which place under the prick'd Number, and Subtract it from 287, and there will remain 35: then draw down the next Figure 7, which makes 357, and say, how many times 8 can you have in 35?

which is 4 times; place 4 in the Quotient; then multiply 4 the Quotient by 48 the Diviſor, makes 336, which place under 357, (as in the work;) then draw a line and ſubtract, and there reſts 21; then take down 0 to the Remainder 21, makes 210; then ſay, how many times 8 can you have in 21? the Anſwer is 2; which 2 place in the Quotient, then multiply the 2 by the Diviſor, makes 168, which place under 210, as in the Example; then draw a line and ſubtract it, and there reſts 42.

So that it appears, that if 28770 Pounds is to be divided amongſt 84 men, that there is 342 Pounds comes to each man's ſhare, and $\frac{42}{84}$ of a Pound more.

Now to know what part of a Pound this or any other Fraction is, after the Remainder of any Diviſion; Obſerve this Rule.

Multiply the Remainder 42 by 20, to bring it into Shillings; then divide it by 48, the Diviſor and the Quotient will anſwer the Queſtion, which in this Example, is 10 Shillings more to each man's ſhare, as appears by the work.

42
20
---
84) 840 (10 Shill.
84

00

The

The Rule of Three Direct.

IT is called the *Rule of Three*, becauſe in all Queſtions in this Rule, you have always three Terms given to find a fourth.

It is called the Rule of Proportion for this reaſon; ſee what proportion is between the firſt Term and the ſecond, the ſame proportion is between the third Term and the fourth.

It is called the *Golden Rule* for the Excellency in its Operations.

It is known by { *At*, *If*, *As* } and { *How*, *What*, *So* }

To work this Rule, you muſt multiply the ſecond Term by the Third, for the Dividend; and divide the Product by the firſt, the Quotient will give you the fourth Term demanded.

Here Note; That the firſt and third Number muſt always be of the ſame Denomination; As if one be Pounds, Pence, Yards, Tuns, Hours, Men, *&c.* ſo reſpectively muſt the other be; and the like

is to be underſtood of the ſecond and the fourth, as in the following Example:

If 12 *Yards of Karſey coſt* 3 *Pound, what ſhall* 435 *Yards coſt?*

	l.	*s.*	*d.*
Anſwer	108	15	00

12——3——435 Shilling (1
20 60 2|0)217|5(1
108--15

60) 12)26100(2175
24

21
12

90
74|60

60

Reduce the Shillings into Pounds, by dividing the ſame by 20; and the Anſwer is 108 Pound, 15 Shillings, the price of 435 Yards.

If

If 7 Inches Diameter gives 22 Inches in Circumference what Circumference shall 36 Inches Diameter require?

Answer, 113, 1428 Inches
10000

Example.

If 7——22——36

22

72

72

——— Inches

7)792(113, 1428 parts of
7 ——an Inch.
——— 10000

09

7

22

21

7) 1000 Add Cyphers
7 for the Fra-
——— ction.

7) 30

28 (4

7) 20

14

7) 60

56

4

The

The RULE *of* THREE *REVERSE.*

TO work this Rule, you muſt multiply the firſt Term by the ſecond, and divide the Product by the third, and the Quotient will give you the fourth Term demanded.

If 30 *men require* 25 *Weeks to build a Fort, in how many Weeks will* 20 *Men build the like?*

Anſwer, 37 Weeks, $\frac{1}{2}$

Men	Weeks	Men	Weeks
30	25	20	37 $\frac{1}{2}$
	30		
	750		10
	210)7510		
	37 $\frac{1}{2}$		

The

The Double RULE *of* THREE.

IF 600 *Pounds weight for* 501 *Miles Carriage, coſt* 1 l. 6 s. 6d. *what ſhall* 2500 *Weight coſt* 100 *Miles Carriage?* State the Queſtion thus:

W Miles l. s. d. W. Miles
600—50—1·—6—6—2500—100

To work this, you muſt firſt reduce the Money into the loweſt Denomination expreſs'd, which is 318 Pence; then multiply the 2500 by 100, and alſo by the Number of Pence: All that Product muſt be divided by the two firſt Numbers multiplied together (which is the Diviſor) to divide the other Product by. When the Operation is done, then you muſt reduce the Pence into Shillings, and Shillings into Pounds; and in the Concluſion you will find the Anſwer of the Queſtion to be

l. *s.* *d.*
11———00———10

Note the Work.

Weight	Miles	*l.*	*s.*	*d.*	Weight	Miles
600	50	1	6	6	2500	100

50 26 100

30000 12 25000

52 318

26 200000

312 25000

6 75000

318) 7950000(2650000

30000) 6

19

18

15

15

12)2650000(220834

24

25

24

100

96

40

36

40

36

0416

0416
20

08320
12

16640
8320

10|0840

2|0)22|08
11|04

11 Pound. 10 Pence.

The Work being finiſhed, the Anſwer of the Queſtion is 11 *l.* 10 *d.* the 11 *l.* is apparent, but the 10 *d.* is included in the remaining Fraction 0416. To find the Value of this Fraction in Pence, multiply the Fraction by 20, cutting off 4 Figures, (becauſe there is ſo many in the Fraction.) The Remainder multiply by 12, cutting off ſtill 4 Figures, and there will remain to the Left-hand 10, which is 10 Pence, the value of the Fraction.

The Rule of Three Reverſe.

THE Reverſe, or backward Rule of Three, is to be uſed when the third Number requires leſs, or leſs requires more.

The

The Rule.

Multiply the Firſt Number by the Second, and Divide the Product by the Third, the Quotient will be the Fourth Number ſought; which always ſhall be of the ſame denomination with the Second Number.

For Inſtance.

If 24 Pioneers require 16 Months to dig a Moat about a Town, how many Pioneers muſt there be employed to dig the ſame Moat in 4 Months?

In ſtating this Queſtion, you muſt note, That 24, though it be the Firſt named, is not to be the Firſt Number in the work; becauſe the Middle term muſt always be of the ſame Denomination with that which is ſought; and the Three Numbers put in order ſtand thus.

Months.	*Pioneers.*	*Months.*
16	24	4

Here 'tis plain, leſs requires more; that is, leſs time more hands.

Therefore it muſt be wrought by the Reverſe Rule; and accordingly you may multiply

tiply 24 by 16, and divide the Product by 4, the Quotient will be 96; as doth appear by the work.

Months.	*Pioneers.*	*Months.*
16	24	4

16

144
24

4)384(96 *Pioneers*
36

24
24

0

Which ſhews that 96 Pioneers muſt be employed to finiſh the Moat in 4 Months.

CHAP.

CHAP. II.

A COMPENDIUM OF Decimal Arithmetick.

Note 1ſt.

Notation of FRACTIONS.

Numerators,	5	15	150	1070
Denominators,	10,	100,	1000,	10000.

Note 2d.

Of how many places ſoever the Numerator of a Decimal Fraction doth conſiſt, of ſo

ſo many Cyphers with a Unite before them, do the Donominators conſiſt.

So the Denominator of 5 is 10, of 15 is 100, of 005 is 1000, *&c.*

Note 3d.

When the Numerator of a Decimal Fraction conſiſts not of ſo many places as the Denominator hath Cyphers, prefix ſo many Cyphers on the left hand as is directed in Note 2*d*. So $\frac{5}{10}$ is written thus, 05; $\frac{15}{100}$ is writ thus, 015; $\frac{50}{1000}$ thus, 0050; $\frac{6}{1000}$ thus, 006.

Note 4th.

Cyphers at the end of a Decimal Fraction do neither augment nor diminiſh the value thereof; ſo that 2. 20. 200. 2000, are Decimals of one and the ſame value: For when the Numerator and Denominator do each end with a Cyphor or Cyphers cut off equal Cyphers in both; ſo will the Fraction be reduc'd into leſſer terms,

2	0
10	0
2	00
10	00
2	000
10	000

Thus, $\frac{20}{100}$ $\frac{200}{1000}$ or $\frac{2000}{10000}$

Are reduc'd as in the Table.

Note

Note 5th.

Cyphers added to the left hand of any Number in Decimals, decreaſe it ten fold thus $\frac{0}{10}\frac{1}{00}\frac{5}{0}$.

Note 6th.

To Reduce a Vulgar Fraction to a Decimal.

The Rule.

To the Numerator of the given Fraction add what number of Cyphers you pleaſe, and Divide it by the Denominator, the Quotient is the Decimal Fraction.

Example 1.

I deſire to know what the Decimal Fraction of Sixteen Shillings is, which in a Vulgar Fraction is $\frac{16}{20}$; now you may add to the Numerator 16, what Cyphers you pleaſe: Suppoſe Four, and the work ſtands as follows,

2|0) 16000|0 (8000.

and the Quotient is 8000 for Decimal Fractions of 16 Shillings.

Example

Example 2d.

What is the Decimal of one Peny, which as it is the Fraction of 20 Shillings, (in Vulgar Fractions,) it is thus expreſt, $\frac{1}{240}$. Therefore (as before) add Cyphers to the Numerator 1, and divide by 240, as in this following Example.

```
240) 10000(004166
     960
     ---
     400
     240
     ---
     1600
     1440
     ----
     1600
     1440
     ----
      160
```

Note 7th.

To reduce a Decimal Fraction into a Vulgar.

Rule. Let the Fraction be multiplied by 20; (if it be the Fraction of a Pound Sterling,) and the remaining Decimals by 12; and

and if any more remain, then multiply by 4, to bring them into Farthings; noting this, that in all your Multiplications, you must observe to cut off so many Figures of your Products as there are Figures in the Decimal Fraction..

Example.

I would know the quantity of this Fraction, 396875 of a Pound Sterling; proceed according to the foregoing Rule, and the work will appear as in the following Table to be 11 Shillings, 11 Pence, 1 Farthing.

	20
Shillings.	7|937400
	12
	1974800
	937400
Pence.	11|348800
Farthings.	1|393200

Addition

oly by 4,
ing this,
ou muſt
of your
Decimal

his Fra-
; pro-
le, and
llowing
1 Far-

dition

I would know the quantity of this Fraction, 396875 of a Pound Sterling; proceed according to the foregoing Rule, and the work will appear as in the followin work, to be 7 Shillings, 11 Pence, 1 Farthing.

	396875	
	20	*Shillings.*
Shillings.	7|937500	
	12	*Pence.*
	1875000	
	937500	
Pence.	11|350000	
	4	*Farthings.*
Farthings.	1|200000	

Where you see that I multiply the Fraction by 20, to bring it into Shillings; and that Product by 12, to bring it into Pence; and that Product by 4, to bring it into Farthings.

Addition

Addition of Decimals.

Note 8th.

ADdition of Decimals is the ſame as with whole Numbers, only you muſt obſerve an Order in placing them; (that is,) to place every number under its proper Denomination, whole Numbers under one another, Tenths or Primes under Tenths or Primes, and Seconds under Seconds, *&c.* diſtinguiſhing the whole Numbers from the Fractions by a Point or Comma, and adding them together as whole Numbers, ſtill ſetting down the Exceſs above Ten, and ſo carrying the Tenths to the next place towards the Left hand.

Examples.

l.	
32,6250	,125
36,5025	,630
	67
69,1275	5
	1,925

Subtraction of Decimals.

IN Subtraction of Decimals, obſerve the ſame order in placing them, as is directed in Addition; and then ſubtract the Leſſer from the Greater as in the whole Numbers.

Note 9th.

When the Decimals in both Numbers given, conſiſt not of the ſame number of Places, that Decimal that is defective in places towards the right hand, muſt be filled up with Cyphers, or at leaſt ſuppoſed to be filled up.

Example.

Suppoſe ,47,309 is to be ſubtracted from 54, you are to put ſo many Cyphers as will make up the Fraction, and then Subtract, and the work will ſtand

Thus,	Or thus,
54,000	38, 000
,47 309	0, 130
07691	37, 860

Multi-

Multiplication of Decimals.

Note 10th.

IN any of the Cases which can happen in Multiplication of Decimals, multiply the Numbers given, as if they were whole Numbers, then cut off or separate as many Figures from the Product, by a Point or Comma, as there are Fractions Multiplicand, Multiplicator, or both; which Figures so cut off or separated, are the Fraction of the Product. And the Figures toward the left hand of the point or Comma shall be the Integers or whole number of the Product; and if they do not make so many, they are to be supplyed with a Cypher or Cyphers, which may happen when the Product is a Fraction.

Examples.

I.	II.	III.	IV.
1,406	135,12	,02577	,75
6,74	,42	,034	,0125
5624	27024	10308	375
9842	54048	007731	150
8436			75
	56,7504	,00087618	
9,47644			,009375

Note 11*th.*

In Multiplication of whole Numbers, the Product is always increaſed ſo many times more than the Multiplicand as the Multiplicator contains Unites, as 5 times 4 make 20: But in Multiplication of Fractions, the Product is always leſs than either of the two Numbers alone, as in Example the IV, where you ſee one Number is 75, the Decimal of 15 Shillings, and the other 0125, the Decimal of three Pence; yet the Product of the Multiplication is but the Decimal of 2 Pence Farthing, as you may ſee if you look forward in the Decimal Table of Pence and Farthings, *pag.* 46.

The Reaſon is, becauſe 1 being multiplied by one, can produce but one; therefore that which is leſs than 1, as (are all proper Fractions,) being Multiplied by that which is leſs than 1, muſt needs be diminiſhed by the Multiplication. And this Diminution bears the ſame Proportion to the Multiplicator, as the Multiplicand beareth to a Unite.

For as 15 Shillings the Multiplicand is $\frac{3}{4}$ of a Pound, ſo Two Pence Farthing the Product is $\frac{3}{4}$ of the Multiplicator 3 Pence.

Diviſion

Diviſion of Decimals.

Note 12th.

IN Diviſion of Decimals, the Dividend muſt ſometimes be prepared, by adding a competent number of Cyphers to make room for the Diviſor to find out a Fraction, and for the Reduction of Vulgar Fractions into Decimals.

Note 13th.

In the whole Doctrine of Decimal Arithmetick, there is no part ſo difficult as this of Diviſion, in regard to the variety of operation, in reſpect of the Quotient, what part of it to cut off in the various Diviſions of whole Numbers with Fractions, and Fractions with Fractions, *&c.* all which varieties ſhall be ſolved with this enſuing Rule.

A General Rule to know the true value of the Quotient.

THere muſt be ſo many Figures cut off in the Quotient, as will make thoſe in the Diviſor (if any be) equal to the Number of Decimal parts in the Dividend.

Note 14th.

If the Quotient doth not conſiſt of as many places as are required by the General Rule to be cut off, you may ſupply that defect by prefixing a Cypher or Cyphers before the Quotient toward the left hand.

Example 1.

To Divide a whole Number by a Fraction.

Suppoſe the whole Number to be 82, which is required to be divided by this Fraction ,056, becauſe there is a defect of Figures in the Dividend 82; therefore I add 5 Cyphers thereto, and place them in their due order, and when the work is finiſhed, you will find 6 Figures come in the Quotient. (Now the Queſtion is,) how many of theſe Figures are proper to be cut off for a Fraction; therefore note, that there being three Decimal Fractions in the Diviſor, and 5 in the Dividend, therefore I cut off the laſt Figures in the Quotient, which being added to the 3 Figures in the Diviſor, makes them equal to the Fraction in the Dividend, which is 5 Cyphers; ſo the general

neral Rule is made good, as you may see in the work.

Dividend.

Divisor, ,056) 82,00000(1464,28 Quotient

56

260
224

360
336

240
224

160
112

480
448

32 Remainer.

Example 2.

To divide a Fraction by a whole Number.

Here (according to the 9*th* Note,) I pre-

fix a Cypher before the Quotient, there being (after the Diviſion is finiſhed) only Four Figures in the Quotient; ſo then there are 5 Figures in the Dividend and 5 in the Quotient, according to the general Rule; as you may ſee in the work.

```
26),35673(.01372
   26
   --
   96
   78
   --
  187
  182
  ---
   53
   52
   --
    1
```

Example

Example 3.

To Divide a whole Number, and a Fraction by a Fraction.

```
,75)45,275000(60,3666
   450
  -----
    275
    225
  -----
     500
     450
  -----
      500
      450
  -----
```

Here you see 4 Figures are cut off in the Quotient, which with the 2 in the Divisor, makes 6, which is equal to the Decimal parts in the Dividend; according to the General Rule in *pag.* 37, aforegoing.

Example

Example 4.

To divide a Fraction by a whole Number and a Fraction.

```
                .....
12,25),9500000(07755
       8575
       ----
        9250
        8575
        ----
        6750
        6125
        ----
        6250
        6125
        ----
         125
```

Here are 7 Decimals in the Dividend, and when the Diviſion is finiſhed, there are 4 Figures in the Quotient, which with the 2 in the Diviſor, makes but 6; Therefore according to the 9*th* note, I prefix a Cypher before the Quotient on the left hand, and then they are equal.

Example

Example 5.

To divide a Fraction by a Fraction.

,008),8564000(107,050

According to the General Rule I cut off 4 Figures to the Right hand in the Quotient, which makes those in the Divisor equal to those in the Dividend.

8
056
56
40
40
00

Example 6.

To divide a whole Number and a Fraction by a whole Number.

23) 135,54(5,89
115
205
184
214
207
4

Here are only 2 Figures to be separated in the Quotient; there being no Decimals in

in the Divisor, and only 2 in the Dividend.

Example 7.

To Divide a whole Number by a whole Number and a Fraction.

```
75,85)200,0000000(2,63678
      15170
      -----
       48300
       45510
       -----
        27900
        22755
        -----
         51450
         45510
         -----
          59400
          53095
          -----
           63050
           58680
           -----
            4370
```

There being 7 Decimals in the Dividend, I therefore cut off 5 Figures in the Quotient,

Quotient, which with the 2 in the Diviſor, make 7 according to the General Rule. *p.* 37.

Example 8.

To divide a whole Number and a Fraction, by a whole Number and a Fraction.

```
3,756) 172,500000 (46,049
       14984
       -----
        22660
        22476
        -----
         18400
         14984
         -----
          34160
          33714
          -----
            346
```

According to Note *9th* (in *pag.* 34,) add Cyphers to the Dividend, and when the work is finiſhed, I find 5 Figures in the Quotient, 3 of which muſt be cut off, that they may make thoſe of the Diviſor 6, equal to the Decimals in the Dividend, according to the Rule.

A Decimal Table of Pence and Farthings.

Pence. Farth.	*Decimal.*	*Pence. Farth.*	*Decimal.*
I	0010416	I	0260416
2	0020833	2	0270833
3	0031250	3	0281250
I	0041666	VII	0291666
I	0052083	I	0302083
2	0062500	2	0312500
3	0072916	3	0322916
II	0083333	VIII	0333333
I	0093750	I	0343750
2	0104166	2	0354166
3	0114583	3	0364583
III	0125000	IX	0375000
I	0135416	I	0385416
2	0145833	2	0395833
3	0156250	3	0406250
IV	0166666	X	0416666
I	0177083	I	0427083
2	0187500	2	0437500
3	0197916	3	0447916
V	0208333	XI	0458333
I	0218750	I	0468750
2	0229166	2	0479166
3	0239583	3	0489583
VI	0250000	XII	0500000

Pence. Farth.	Decimal.	Pence. Farth.	Decimal.
1	0510416	1	0760416
2	0520833	2	0770833
3	0531250	3	0781250
XIII	0541666	XIX	0791666
1	0552083	1	0802083
2	0562500	2	0812500
3	0572916	3	0822916
XIV	0583333	XX	0833333
1	0593750	1	0843750
2	0604166	2	0854166
3	0614583	3	0864183
XV	0625000	XXI	0875000
1	0635416	1	0885416
2	0645833	2	0895833
3	0656250	3	0906250
XVI	0666666	XXII	0916666
1	0677083	1	0927084
2	0687500	2	0937500
3	0597916	3	0947916
XVII	0708333	XXIII	0958333
1	0718750	1	0968750
2	0729166	2	0979166
3	0739583	3	0989583
XVIII	0750000	XXIV	1000000

A Table of Decimals of one Pound Sterling in Shillings.

Sh.	Decim.
1	050000
2	100000
3	150000
4	200000
5	250000
6	300000
7	350000
8	400000
9	450000
10	500000
11	550000
12	600000
13	650000
14	700000
15	750000
16	800000

Sh.	Decim.
17	850000
18	900000
19	950000
20	100000
21	105000
22	110000
23	115000
24	120000
25	125000
26	130000
27	1350000
28	1400000
29	1450000
30	1500000
31	1550000

A Table of the Decimals of a Foot to every Inch and Eighth part of an Inch.

Inches. 8 *Part.*	*Decimal.*
I	001041
2	002083
3	003125
4	004166
5	005208
6	006250
7	007291
I	008333
I	009375
2	010416
3	011458
4	012500
5	013541
6	014583
7	015625
II	016666

Inches. 8 *Part.*	*Decimal.*
I	017708
2	018750
3	019791
4	020833
5	021875
6	022926
7	023958
III	025000
I	026041
2	027208
3	028125
4	029166
5	030200
6	031299
7	032291
IV	033333

Inches. & Part.	Decimal.
1	034385
2	035416
3	037395
4	037499
5	038541
6	039583
7	040625
V	041666
1	042610
2	043750
3	044718
4	045833
5	046875
6	047927
7	048854
VI	050000
1	051104
2	052083
3	053125
4	054166
5	055207
6	056250
7	057291
VII	058333

Inches. & Part.	Decimal.
1	059375
2	051041
3	061457
4	062500
5	063531
6	064583
7	065625
VIII	066000
1	067610
2	068750
3	059896
4	070833
5	071875
6	072916
7	073958
IX	075000
1	076041
2	077083
3	078125
4	079166
5	080208
6	081250
7	082291
X	083333

Inches. 8 *Part.*	*Decimal.*
1	084375
2	085416
3	086457
4	087500
5	088541
6	089687
7	090625
XI	091666

Inches. 8 *Part.*	*Decimal.*
1	092708
2	093750
3	094791
4	095833
5	096875
6	097926
7	098958
XII	100000

The Calculating of this Table, is by Dividing every Inch and 8 Parts by 96, becauſe there are ſo many parts in the Foot, every Inch being divided into 8 Parts, ſerving to Reduce Inches and 8 Parts to the Decimals of a Foot, or the contrary.

An Explanation of this Table.

The Firſt Column ſhews the Inches and Eight parts of a Foot, and the Second Column ſhews the Decimal Number anſwering thereto.

Example.

Seek for 11 Inches, and $\frac{4}{8}$ or a half in the Firſt Collumn, and in the next you will find the Decimal thereof 095833.

CHAP. III.

THE EXTRACTION OF THE Square Root.

THe Extraction of the Square Root is that by which having a number given, another number may be found, which being Multiplied by itſelf, produceth the number required.

Any Square number being given to be Extracted, thus it may be prepared. According to this Rule, put a Point over the firſt place thereof to the Right hand (being the place of Unites;) then proceeding towards the left hand, paſs over the ſecond place, and put a Point over the third place; alſo

alſo paſſing over the Fourth place, put another Point over the Fifth, and ſo forward in ſuch manner, that between every Two Points which are next one to another; ſo that one place may be intermitted according to this Example, 630436. Suppoſe the Square Root of this Number be required; the Firſt Point is to be placed over 6, and the Second over 4, and ſo of the reſt as you ſee in the Example; and note, that as many Points as are placed in that manner, of ſo many Figures will the Root be.

To fit it for operation, draw a crooked Line on the Right hand of the Number propounded for Extraction, then find the Root of the Firſt Square, and place it in the Quotient, which in this Example is found to be 7;

```
  630436 (794
  49
149) 140436   Reſolvend.
  1341
158) 6336
  632
    16
```

Then Square the Quotient which is 49, and place it under the firſt Square of the Num-

ber given, (*viz.*) 63, and Subtract the 49 from the Firſt Square; and place the Remainder orderly underneath the Line, which is 14, to which Remainder being down, the next Squares of the Number propounded, and place them on the Right hand of the ſaid Remainder; (and may now be called the Reſolvend.) Then double the Root, being the Number placed in the Quotient, which is 14, and place them on the Left hand of the Reſolvend (like a Diviſor,) parted off with a Crooked Line.

Then demand how often that Diviſor is contained in the Reſolvend, which may be now called the Dividend (proceeding in all reſpects as you do in Diviſion,) and write the anſwer in the Quotient on the Right hand of the Diviſor; then if you ask how often the Diviſor 149 is found in the Dividend 1404, the Anſwer is 9 times: Therefore write 9 in the Quotient, and alſo after the Diviſor 14.

Then Multiply all the Numbers which ſtand on the Left hand of the Reſolvend, *viz.* (before the Crooked Line,) and write the Product orderly underneath the Reſolvend; then having drawn a Line under the ſaid Product, ſubtract it from the Reſolvend, and ſubſcribe the Remainder under the Line which is 63: unto which Number

ber bring down the remaining Figures of the Reſolvend, and then there will be 6336 at the Left hand, of which number draw another Crooked Line; then double the Quotient, which is 158, and ſet it on the Left hand of the ſaid Crooked Line; then demand how often you may have 158 in 633: the Anſwer is 4, which 4 muſt be placed in the Quotient; then multiply that by each Figure of the Diviſor, and ſubſcribe the Product orderly under the Dividend, and ſubtract it therefrom, and there remains 16; ſo the work is finiſhed, and the Square Root of that Number 630436 is 794, and 16 which remains, intimates that the Root is ſomething greater than 794, but leſs than 795; yet how much greater than 794 is not yet diſcovered by any Rules of Art. But farther Progreſs may be made for a nearer diſcovery of the truth; but in this caſe it being but a ſmall difference, I ſhall wave it.

To Extract the Square Root by the Logarithms.

The Rule.

HAlf the Logarithm of any Number, is the Logarithm of the Square Root thereof.

Example.

Let the Square Number given be 5625,

The Logarithm of 625 is——2,79588
The half thereof is——1,39794

which is the Logarithm of 25, the Root of the ſaid Number.

By Gunter's *Scale.*

To Extract the Square Root, is to find a mean proportional Number between 1 and the Number given; therefore divide the Space between them into Two Equal parts, and that ſhall be the Root ſought.

Example.

Example.

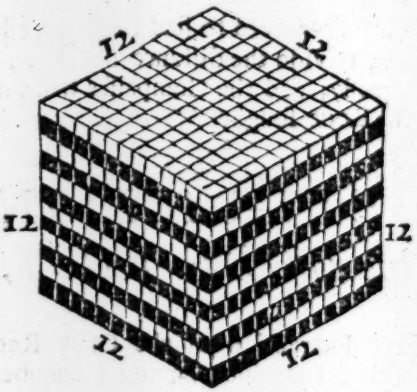
Let it be required to find the Square Root of 144; Divide the distance betwixt 1 and 144 equally, and the Compasses will fall on 12, the Root sought.

The EXTRACTION of the CUBE ROOT.

THe Extraction of the Cube Root is that by which having a Number given, another may be found, which being first Multiplied by itself, and then by the Product produceth the Number given.

In the Extraction of the Cube Root, the Number propounded is always conceived to be a Cubical Number; that is, a certain Number of little Cubes, comprehended within one entire great Cube, so that the Root of any perfect Cubical Number is a Right Line of a Solid Body, containing 6. Equal Sides, which constitutes as many Square Superficies, or a Number Multiplied twice in itself, which in the Solid, hath length, breadth and depth, as may more plainly

plainly appear in this Annexed Cubical Figure.



A Cube Number is either Single or Compound.

A Single Cube Number is that which is produced by the Multiplication of one single Figure, first by itself, and then by the Product, and is always less than 100; so 64 is a single Cube Number produced by the Multiplication of 4, First by itself, and then by the Product as in the Margin.

4
4
16
4
64

A Compound Cube Number, is when there are Two Figures in the Root.

All

All the Single Cube Numbers and Square Numbers, together with their respective Roots, are expressed in this Table following.

Cubes,	1	8	27	64	125	216	343	512	729	1000
Squar.	1	4	9	16	25	36	49	64	81	100
Roots,	1	2	3	4	5	6	7	8	9	10

To prepare a Cube Number for Extraction.

The Rule.

Put a Point over the First place thereof, towards the Right hand, (*viz.*) the place of Unites, then passing over the Second and Third places, put another over the Fourth, and passing over the Fifth and Sixth, put another over the Seventh, always observing the same order in intermitting Two Places (between every Two Adjacent Points) place as many Points as the Number will permit, as may plainly appear in this Example. Let 1728 be the

the Number given, place the Points according to this Rule.

```
1728 (12
1
----
0728   Resolvend.
 3
 3
----
 33    Divisor.
----
 6
 12
  8
----
 728
----
   0
```

Which done, draw a Crooked Line on the Right hand of the Number to signify a Quotient; then find the Cube Root of the First Cube which is 1, as you may see in the Table, which 1 set in the Quotient. Then subscribe the Cube of the Root placed in the Quotient, under the First Cube of the Number given, which in this Example is 1.

Then

Then draw a Line under the Cube ſubſcribed aforeſaid, and ſubtract this Cube from the Firſt Cube, and place the Remainder orderly underneath the Line, which in this Example is nothing; to which Remainder, bring down the ne x Cube, which is 728, placing it on the Right hand of the Remainder, which number ſo placed, may be called the Reſolvend; having drawn a Line underneath the Reſolvend, Square the Root in the Quotient, that is, multiply it in itſelf, and ſubſcribe 3 the Triple of the ſaid Square or Product under the Reſolvend, and place it under 7, the place of Hundreds.

Then Triple the Root or Number in the Quotient, which is 3, and ſubſcribe this Triple Number in ſuch a manner, that the Firſt place thereof, (the place of Unites,) may ſtand under the Second place, (the place of Tens) in the Reſolvend, which Triple is Three which I place under 2: Then the Triple Square of the Root, and the Triple of the Root being ſo placed, draw a Line under them, and add them together, the Sum is 33 for a Diviſor.

Then let the whole Reſolvend, except the Firſt place thereof towards the Right hand, (*viz.*) the place of Unites, be eſteemed as a Dividend; then demanding how often the

the Firſt Figure (towards the Left hand) of the Diviſor is contained in the correſpondent part of the Dividend, write the Anſwer in the Quotient; for if I ask how many times Three in 7, the Anſwer is twice, therefore I place 2 in the Quotient.

Then draw another Line under the work, and multiply the Triple Square before ſubſcribed (under 7) by the laſt Figure placed in the Quotient, which is 2, and ſay, 2 times 3 is 6; which Product I ſubſcribe under the ſaid Triple Square (*viz.*) under the 3, which ſtands under the 7, as you may ſee in the work.

Then Multiply the Figure laſt placed in the Quotient, namely 2, by the Triple Number before ſubſcribed under 2 in the Reſolvend; for 2 being multiplied by itſelf, produceth 4, which being multiplied by the Triple Number 3, the Product is 12, which I ſubſcribe with the 1 under 6, and the 2 under 3; as in the work may appear.

Then Cube the laſt Figure in the Quotient which is 8, which place in ſuch manner, that it may ſtand under the place of Unites in the Reſolvend, as you may ſee in the work.

Laſtly, Draw a Line under all, and add up the Three laſt Numbers together in the ſame

same order as they are placed, and the Sum is 728, which being Subtracted from the Resolvend, and there remaineth 0; so the Cubic Root is found to be 12.

Note when the Sum of the Three last Numbers before mentioned, is greater than the Resolvend, the work is erronious, and then you may reform it, by placing a Figure less in the Quotient.

To Extract the Cube Root by the Logarithms.

The Rule.

Divide the Logarithm of the given Number by 3, so shall you have the Logarithm of the Root required.

Example.

Let the Cube Number given be 1728 as before,

The Logarithm of 1728 is——3,23754
The Third part thereof is——1,07918

which is the Logarithm of 12, the Cube Root required.

Like-

Likewiſe Multiply the Logarithm of any Number by Three, and it produceth the Logarithm of the Cube thereof.

To Extract the Cube Root by Gunter's *Scale.*

TO Extract the Cube Root, is to find the Firſt of Two Mean Proportionals between 1, and the Number whoſe Cube Root you require; therefore you muſt Divide the ſpace between thoſe Two Numbers into Three equal parts.

Example.

Let it be required to find the Cube Root of 1728, as before: Divide the diſtance between 1 and 1728, into Three Equal parts, one Third part of that diſtance ſhall reach from 1 to 12, which is the Cube Root required.

A Table of Square Roots from One to an Hundred.

R.	Sq.	R.	Sq.	R.	Sq.	R.	Sq.
1	1	26	676	51	2601	76	5776
2	4	27	729	52	2704	77	5929
3	9	28	784	53	2809	78	6084
4	16	29	841	54	2916	79	6241
5	25	30	900	55	3025	80	6400
6	36	31	961	56	3136	81	6561
7	49	32	1024	57	3249	82	6724
8	64	33	1089	58	3364	83	6889
9	81	34	1156	59	3481	84	7056
10	100	35	1225	60	3600	85	7225
11	121	36	1296	61	3721	86	7396
12	144	37	1369	62	3844	87	7569
13	169	38	1444	63	3969	88	7744
14	196	39	1521	64	4096	89	7921
15	225	40	1600	65	4225	90	8100
16	256	41	1681	66	4356	91	8281
17	289	42	1764	67	4489	92	8464
18	324	43	1849	68	4624	93	8649
19	361	44	1936	69	4761	94	8836
20	400	45	2025	70	4900	95	9025
21	441	46	2116	71	5041	96	9216
22	484	47	2209	72	5184	97	9409
23	529	48	2304	73	5329	98	9604
24	576	49	2401	74	5476	99	9801
25	625	50	2500	75	5625	100	10000

A Table of Cubick Roots from One to an Hundred.

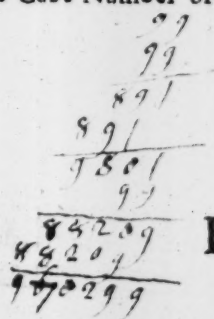
R.	Cube.	R.	Cube.	R.	Cube.	R.	Cube.
1	1	26	17576	51	135651	76	438976
2	8	27	19683	52	140608	77	456533
3	27	28	21972	53	148877	78	474522
4	64	29	24389	54	157464	79	493039
5	125	30	27000	55	167375	80	512000
6	216	31	29791	56	175616	81	531441
7	343	32	32768	57	185193	82	550408
8	512	33	35937	58	195112	83	571787
9	729	34	39304	59	205379	84	592604
10	1000	35	42825	60	216000	85	614125
11	1331	36	48656	61	226981	86	636056
12	1728	37	50653	62	238328	87	648303
13	2197	38	54872	63	293047	88	681472
14	2744	39	55419	64	262244	89	705669
15	3375	40	64000	65	274625	90	729000
16	4096	41	68921	66	287496	91	753571
17	4913	42	74088	67	300753	92	778688
18	5832	43	79507	68	314432	93	804357
19	6859	44	85184	59	329195	94	830584
20	8000	45	91125	70	333000	95	857375
21	9261	46	97336	71	357911	96	884736
22	10648	47	103823	72	373348	97	915673
23	2167	48	110592	73	389017	98	941192
24	3824	49	117645	74	405224	99	970299
25	5625	50	125000	75	411875	100	1000000

To make the Table of Square Roots.

The Table of Square Roots is made by Multiplying each Figure into itſelf; the Product is the Square of the Number required. As for Example in the Root 29, which being Multiplied in itſelf, produceth 841, the Square of that Number is 29.

To make the Tables of Cubick Roots.

The Table of Cubick Roots, are made by Multiplying the Root in itſelf; and that Product again by the Root, and the laſt Number is the Cube Number required. As for Example in the Root 12, which being Multiplied in itſelf, produceth 144, that being Multiplied by 12, produceth 1728, the Cube Number of 12.



A TABLE OF LOGARITHMS OF

Absolute Numbers, from One to a Thousand.

Num.	Logar.	N.	Logar.	N.	Logar.
1	0,00000	13	1,11394	25	1,39794
2	0,30103	14	1,14613	26	1,41497
3	0,47712	15	1,17609	27	1,43136
4	0,60206	16	1,20412	28	1,44716
5	0,69897	17	1,23045	29	1,46239
6	0,77815	18	1,25527	30	1,47712
7	0,84510	19	1,27875	31	1,49136
8	0,90309	20	1,30103	32	1,50515
9	0,95424	21	1,32222	33	1,51851
10	1,00000	22	1,34242	34	1,53148
11	1,04139	23	1,36173	35	1,54407
12	1,07918	24	1,38021	36	1,55630

N.	*Logar.*	*N.*	*Logar.*	*N.*	*Logar.*
37	1,56820	61	1,78533	85	1,92942
38	1,57978	62	1,79239	86	1,93450
39	1,59106	63	1,79934	87	1,93952
40	1,60206	64	1,80618	88	1,94448
41	1,61278	65	1,81291	89	1,94939
42	1,62325	66	1,81954	90	1,95424
43	1,63347	67	1,82607	91	1,95904
44	1,64345	68	1,83251	92	1,96379
45	1,65321	69	1,83885	93	1,96848
46	1,66276	70	1,84510	94	1,97313
47	1,67210	71	1,85126	95	1,97772
48	1,68124	72	1,85733	96	1,98227
49	1,69020	73	1,86332	97	1,98677
50	1,69897	74	1,86923	98	1,99123
51	1,70757	75	1,87506	99	1,99563
52	1,71600	76	1,88081	100	2,00000
53	1,72428	77	1,88649	101	2 00432
54	1,73239	78	1,89209	102	2,00860
55	1,74036	79	1,89763	103	2,01284
56	1,74819	80	1,90309	104	2,01703
57	1,75587	81	1,90848	105	2,02119
58	1,76343	82	1,91381	106	2,02531
59	1,77085	83	1,91908	107	2,02938
60	1,77815	84	1,92428	108	2,03342

N.	Logar.	N.	Logar.	N.	Logar.
109	2,03743	133	2,12385	157	2,19590
110	2,04139	134	2,12710	158	2,19866
111	2,04532	135	2,13033	159	2,20140
112	2,04922	136	2,13354	160	2,20412
113	2,05308	137	2,13672	161	2,20683
114	2,05690	138	2,13988	162	2 20951
115	2,06070	139	2,14301	163	2,21219
116	2,06446	140	2,14613	164	2,21484
117	2,06819	141	2,14922	165	2,21748
118	2,07188	142	2,15229	166	2,22011
119	2,07555	143	2,15534	167	2,22272
120	2,07918	144	2,15836	168	2,22531
121	2,08278	145	2,16137	169	2,22789
122	2,08636	146	2,16435	170	2,23045
123	2,08990	147	2,16732	171	2,23300
124	2,09342	148	2,17026	172	2,23553
125	2,09691	149	2,17319	173	2,23805
126	2,10037	150	2,17609	174	2,24055
127	2,10380	151	2,17898	175	2,24304
128	2,10721	152	2,18184	176	2,24551
129	2,11059	153	2,18469	177	2,24797
130	2,11394	154	2,18752	178	2,25042
131	2,11727	155	2,19033	179	2,25285
132	2,12057	156	2,19312	180	2.25227

N.	*Logar.*	*N.*	*Logar.*	*N.*	*Logar.*
181	2,25768	205	2,31175	229	2,35983
182	2,26007	206	2,31387	230	2,36173
183	2,26245	207	2,31597	231	2,36361
184	2,26482	208	2,31806	232	2,36549
185	2,26717	209	2,32015	233	2,36736
186	2,26951	210	2,32222	234	2,36922
187	2,27184	211	2,32428	235	2,37107
188	2,27416	212	2,32634	236	2,37291
189	2,27646	213	2,32828	237	2,37475
190	2,27875	214	2,33041	238	2,37658
191	2,28108	215	2,33244	239	2,37840
192	2,28330	216	2,33445	240	2,38021
193	2,28550	217	2,33646	241	2,38202
194	2,28780	218	2,33846	242	2,38381
195	2,29003	219	2,34044	243	2,38561
196	2,29226	220	2,34223	244	2,38739
197	2,29447	221	2,34439	245	2,38917
198	2,29666	222	2,34635	246	2,39093
199	2,29884	223	2,34830	247	2,39270
200	2,30103	224	2,35025	248	2,39445
201	2,30320	225	2,35218	249	2,39620
202	2,30535	226	2,35411	250	2,39794
203	2,30750	227	2,35603	251	2,39967
204	2,30963	228	2,35793	252	2,40140

N.	Logar.	N.	Logar.	N.	Logar.
253	2,40312	277	2,44248	301	2,47857
254	2,40483	278	2,44404	302	2,48001
255	2,40654	279	2,44560	303	2,48144
256	2,40824	280	2,44716	304	2,48287
257	2,40993	281	2,44871	305	2,48430
258	2,41162	282	2,45025	306	2,48572
259	2,41330	283	2,45179	307	2,48714
260	2,41497	284	2,45332	308	2,48855
261	2,41664	285	2,45484	309	2,48996
262	2,41830	286	2,45636	310	2,49136
263	2,41996	287	2,45788	311	2,49276
264	2,42160	288	2,45939	312	2,49415
265	2,42325	289	2,46090	313	2,49554
266	2,42488	290	2,46240	314	2,49693
267	2,42651	291	2,46389	315	2,49831
268	2,42813	292	2,46538	316	2,49969
269	2,42975	293	2,46687	317	2,50106
270	2,43136	294	2,46835	318	2,50243
271	2,43297	295	2,46982	319	2,50379
272	2,43457	296	2,47129	320	2,50515
273	2,43616	297	2,47276	321	2,50650
274	2,43775	298	2,47422	322	2,50786
275	2,43933	299	2,47567	323	2,50920
276	2,44091	300	2,47712	324	2,51054

N.	Logar.	N.	Logar.	N.	Logar.
325	2,51188	349	2,54282	373	2,57171
326	2,51322	350	2,54407	374	2,57287
327	2,51455	351	2,54531	375	2,57403
328	2,51587	352	2,54654	376	2,57519
329	2,51720	353	2,54777	377	2,57634
330	2,51851	354	2,54900	378	2,57749
331	2,51983	355	2,55023	379	2,57864
332	2,52114	356	2,55145	380	2,57978
333	2,52244	357	2,55267	381	2,58092
334	2,52375	358	2,55388	382	2,58206
335	2,52504	359	2,55509	383	2,58320
336	2,52634	360	2,55630	384	2,58433
337	2,52763	361	2,55751	385	2,58546
338	2,52892	362	2,55871	386	2,58659
339	2,53020	363	2,55991	387	2,58771
340	2,53148	364	2,56110	388	2,58883
341	2,53275	365	2,56229	389	2,58995
342	2,53403	366	2,56348	390	2,59106
343	2,53529	367	2,56467	391	2,59218
344	2,53656	368	2,56585	392	2,59329
345	2,53782	369	2,56703	393	2,59439
346	2,53908	370	2,56820	394	2,59549
347	2,54033	371	2,56937	395	2,59660
348	2,54158	372	2,57054	396	2,59769

N.	Logar.	N.	Logar.	N.	Logar.
397	2,59879	421	2,62428	445	2,64836
398	2,59988	422	2,62531	446	2,64933
399	2,60097	423	2,62634	447	2,65031
400	2,60206	424	2,62737	448	2,65128
401	2,60314	425	2,62839	449	2,65225
402	2,60423	426	2,62941	450	2,65321
403	2,60530	427	2,63043	451	2,65418
404	2,60638	428	2,63144	452	2,65514
405	2,60745	429	2,63246	453	2,65610
406	2,60853	430	2,63347	454	2,65706
407	2,60959	431	2,63448	455	2,65801
408	2,61066	432	2,63548	456	2,65896
409	2,61172	433	2,63649	457	2,65991
410	2,61278	434	2,63749	458	2,66086
411	2,61384	435	2,63849	459	2,66181
412	2,61490	436	2,63949	460	2,66276
413	2,61595	437	2,64048	461	2,66370
414	2,61700	438	2,64147	462	2,66464
415	2,61805	439	2,64246	463	2,66558
416	2,61909	440	2,64345	464	2,66652
417	2,62014	441	2,64444	465	2,66745
418	2,62118	442	2,64542	466	2,66838
419	2,62221	443	2,64640	467	2,66932
420	2,62325	444	2,64738	468	2,67024

N.	Logar.	N.	Logar.	N.	Logar.
469	2,67117	493	2,69285	517	2,71349
470	2,67210	494	2,69373	518	2,71433
471	2,67302	495	2,69460	519	2,71517
472	2,67394	496	2,69548	520	2,71600
473	2,67486	497	2,69636	521	2,71684
474	2,67578	498	2,69723	522	2,71767
475	2,67669	499	2,69810	523	2,71850
476	2,67761	500	2,69897	524	2,71933
477	2,67852	501	2,69984	525	2,72016
478	2,67943	502	2,70070	526	2,72099
479	2,68033	503	2,70157	527	2,72181
480	2,68124	504	2,70243	528	2,72263
481	2,68214	505	2,70329	529	2,72346
482	2,68305	506	2,70415	530	2,72428
483	2,68395	507	2,70501	531	2,72509
484	2,68484	508	2,70586	532	2,72591
485	2,68574	509	2,70672	533	2,72673
486	2,68664	510	2,70757	534	2,72754
487	2,68753	511	2,70842	535	2,72835
488	2,68842	512	2,70927	536	2,72916
489	2,68931	513	2,71012	537	2,72997
490	2,69020	514	2,71096	538	2,73078
491	2,69108	515	2,71181	539	2,73159
492	2,69196	516	2,71265	540	2,73239

N.	Logar.	N.	Logar.	N.	Logar.
541	2,73320	565	2,75205	589	2,77011
542	2,73400	566	2,75282	590	2,77085
543	2,73480	567	2,75358	591	2,77159
544	2,73560	568	2,75435	592	2,77232
545	2,73640	569	2,75511	593	2,77305
546	2,73719	570	2,75587	594	2,77379
547	2,73799	571	2,75664	595	2,77452
548	2,73878	572	2,75740	596	2,77525
549	2,73957	573	2,75815	597	2,77597
550	2,74036	574	2,75891	598	2,77670
551	2,74115	575	2,75967	599	2,77743
552	2,74191	576	2,76042	600	2,77815
553	2,74272	577	2,76118	601	2,77887
554	2,74351	578	2,76193	602	2,77960
555	2,74429	579	2,76268	603	2,78032
556	2,74507	580	2,76343	604	2,78104
557	2,74585	581	2,76418	605	2,78175
558	2,74663	582	2,76492	606	2,78247
559	2,74741	583	2,76567	607	2,78319
560	2,74819	584	2,76641	608	2,78390
561	2,74896	585	2,76716	609	2,78462
562	2,74973	586	2,76790	610	2,78533
563	2,75051	587	2,76864	611	2,78604
564	2,75128	588	2,76938	612	2,78675

N.	Logar.	N.	Logar.	N.	Logar.
613	2,78746	637	2,80414	661	2,82020
614	2,78816	638	2,80482	662	2,82086
615	2,78887	639	2,80550	663	2,82151
616	2,78958	640	2,80618	664	2,82217
617	2,79028	641	2,80686	665	2,82282
618	2,79099	642	2,80753	666	2,82347
619	2,79169	643	2,80821	667	2,82413
620	2,79239	644	2,80889	668	2,82478
621	2,79309	645	2,80956	669	2,82543
622	2,79379	646	2,81023	670	2,82607
623	2,79449	647	2,81090	671	2,82672
624	2,79518	648	2,81157	672	2,82737
625	2,79588	649	2,81224	673	2,82801
626	2,79657	650	2,81291	674	2,82866
627	2,79727	651	2,81358	675	2,82930
628	2,79796	652	2,81425	676	2,82995
629	2,79865	653	2,81491	677	2,83059
630	2,79934	654	2,81558	678	2,83123
631	2,80003	655	2,81624	679	2,83187
632	2,80072	656	2,81690	680	2,83251
633	2,80140	657	2,81756	681	2,83315
634	2,80208	658	2,81822	682	2,83378
635	2,80277	659	2,81888	683	2,83442
636	2,80346	660	2,81954	684	2,83506

N.	Logar.	N.	Logar.	N.	Logar.
685	2,83569	709	2,85065	733	2,86510
686	2,83632	710	2,85126	734	2,86570
687	2,83696	711	2,85187	735	2,86629
688	2,83759	712	2,85248	736	2,86688
689	2,83822	713	2,85301	737	2,86747
690	2,83885	714	2,85370	738	2,86806
691	2,83948	715	2,85431	739	2,86864
692	2,84011	716	2,85491	740	2,86923
693	2,84073	717	2,85552	741	2,86982
694	2,84136	718	2,85612	742	2,87040
695	2,84198	719	2,85673	743	2,87099
696	2,84261	720	2,85733	744	2,87157
697	2,84323	721	2,85793	745	2,87216
698	2,84385	722	2,85854	746	2,87274
699	2,84448	723	2,85914	747	2,87332
700	2,84510	724	2,85974	748	2,87390
701	2,84572	725	2,86034	749	2,87448
702	2,84634	726	2,86094	750	2,87506
703	2,84695	727	2,86153	751	2,87564
704	2,84757	728	2,86213	752	2,87622
705	2,84819	729	2,86273	753	2,87679
706	2,84880	730	2,86332	754	2,87737
707	2,84942	731	2,86392	755	2,87795
708	2,85001	732	2,86451	756	2,87852

N.	Logar.	N.	Logar.	N.	Logar.
757	2,87910	781	2,89265	805	2,90580
758	2,87967	782	2,89321	806	2,90633
759	2,88024	783	2,89376	807	2,90687
760	2,88081	784	2,89431	808	2,90741
761	2,88138	785	2,89487	809	2,90795
762	2,88195	786	2,89542	810	2,90848
763	2,88252	787	2,89597	811	2,90902
764	2,88309	788	2,89653	812	2,90956
765	2,88361	789	2,89708	813	2,91005
766	2,88423	790	2,89763	814	2,91062
767	2,88479	791	2,89818	815	2,91116
768	2,88536	792	2,89872	816	2,91169
769	2,88592	793	2,89927	817	2,91222
770	2,88649	794	2,89982	818	2,91277
771	2,88705	795	2,90037	819	2,91328
772	2,88762	796	2,90091	820	2,91381
773	2,88818	797	2,90146	821	2,91434
774	2,88874	798	2,90200	822	2,91487
775	2,88930	799	2,90255	823	2,91540
776	2,88986	800	2,90309	824	2,91593
777	2,89042	801	2,90363	825	2,91645
778	2,89093	802	2,90417	826	2,91698
779	2,89154	803	2,90472	827	2,91751
780	2,89209	804	2,90526	828	2,91803

N.	Logar.	N.	Logar.	N.	Logar.
829	2,91855	853	2,93095	877	2,94300
830	2,91908	854	2,93146	878	2,94349
831	2,91960	855	2,93197	879	2,94399
832	2,92012	856	2,93247	880	2,94448
833	2,92064	857	2,93298	881	2,94498
834	2,92117	858	2,93349	882	2,94547
835	2,92169	859	2,93399	883	2,94596
836	2,92221	860	2,93450	884	2,94645
837	2,92272	861	2,93500	885	2,94694
838	2,92324	862	2,93551	886	2,94743
839	2,92376	863	2,93601	887	2,94792
840	2,92428	864	2,93651	888	2,94841
841	2,92480	865	2,93701	889	2,94890
842	2,92531	866	2,93752	890	2,94939
843	2,92582	867	2,93802	891	2,94988
844	2,92634	868	2,93852	892	2,95036
845	2,92686	869	2,93902	893	2,95085
846	2,92737	870	2,93952	894	2,95134
847	2,92788	871	2,94001	895	2,95182
848	2,92840	872	2,94052	896	2,95231
849	2,92891	873	2,94102	897	2,95279
850	2,92942	874	2,94151	898	2,95328
851	2,92993	875	2,94201	899	2,95376
852	2,93044	876	2,94250	900	2,95424

N.	Logar.	N.	Logar.	N.	Logar.
901	2,95472	925	2,96614	949	2,97727
902	2,95521	926	2,96661	950	2,97772
903	2,95569	927	2,96708	951	2,97818
904	2,95617	928	2,96755	952	2,97864
905	2,95664	929	2,96802	953	2,97909
906	2,95713	930	2,96848	954	2,97955
907	2,95761	931	2,96895	955	2,98000
908	2,95809	932	2,96941	956	2,98046
909	2,95856	933	2,96988	957	2,98091
910	2,95904	934	2,97035	958	2,98137
911	2,95952	935	2,97081	959	2,98182
912	2,95999	936	2,97128	960	2,98227
913	2,96047	937	2,97174	961	2,98272
914	2,96095	938	2,97220	962	2,98317
915	2,96142	939	2,97267	963	2,98363
916	2,96189	940	2,97313	964	2,98408
917	2,96237	941	2,97359	965	2,98453
918	2,96284	942	2,97405	966	2,98498
919	2,96331	943	2,97451	967	2,98543
920	2,96379	944	2,97497	968	2,98587
921	2,96426	945	2,97543	969	2,98632
922	2,96473	946	2,97589	970	2,98677
923	2,96520	947	2,97635	971	2,98722
924	2,96567	948	2,97681	972	2,98767

N.	Logar.	N.	Logar.	N.	Logar.
973	2,98811	983	2,99255	993	2,99695
974	2,98856	984	2,99299	994	2,99739
975	2,98900	985	2,99344	995	2,99782
976	2,98945	966	2,99388	996	2,99826
977	2,98989	987	2,99432	997	2,99869
978	2,99034	988	2,99476	998	2,99913
979	2,99078	989	2,99520	999	2,99956
980	2,99113	990	2,99563	1000	3,00000
981	2,99167	991	2,99607		
982	2,99211	992	2,99651		

A Description and use of the Table of Logarithms.

THe Table contains all absolute Numbers from One, to One Thousand, (sufficient for any operation in the Art of Gunnery.) In each Page of the Table is contained Six Columns; in the First, the Third and Fifth (towards the Left hand,) are contained all absolute Numbers beginning at 1, and so on by 2, 3, 4, 5, 6, &c. to 1000; (having the Letter *N.* at the Head of each Column.)

Then

Then in the Second, Fourth and Sixth Column of every Page are contained the Logarithmical Numbers, anſwering each abſolute Number, againſt which it ſtandeth, and theſe Columns have at the head of them the word *Logar.* The Numbers being thus diſpoſed in the ſeveral Pages of the Table, it is eaſie to find the Logarithmical Number that anſwers there to any abſolute Number that ſhall be required.

Or on the contrary, if any Logarithmical Number be given, it will be eaſie to find the Abſolute Number to which it belongeth.

For if you find your Abſolute Number in any Column of the Table under the Letter *N.* that Number that ſtandeth in the next Column to it on the Right hand under the Title *Logar.* is the Logarithmical Number thereunto belonging.

And on the contrary, in what part of the Table ſoever you find any Logarithmical Number, that Number which ſtandeth in the next Column on the left hand thereof, is the Abſolute Number ſo found.

And note further, that all the Logarithmical Numbers between 1 and 10, have a Cypher before them; all Numbers between 10 and 100 have the Figure 1 before them; all Numbers between 100 and 1000, have

the Figure 2 before them; which 1 and 2 Figures are called the Characteriſtiques of thoſe Numbers.

And to the end what I have here delivered may be made plain, I ſhall give examples thereof in the Two following Propoſitions.

Prop. 1.

Let it be required to find the Logarithmical Number belonging to 16; turn to the Table in the First Column of the First Page, where you will find 16, under the Letter *N.* and right againſt it towards the Right hand, you ſhall find this Number, 1,20412, which is the Logarithm thereof.

Likewiſe in the ſame Page and Column againſt 25, you will find 1,39794, which is the Logarithm thereof.

Alſo you ſhall (by the ſame Rule) find that

$$\text{The Logarithm of } \left\{\begin{matrix}4\\51\\321\end{matrix}\right\} \text{ will be } \left\{\begin{matrix}0,60206\\1,70757\\2,50650\end{matrix}\right\}$$

and by the Converſe of what is here delivered, you may find the Abſolute Number anſwering to any given Logarithms as in the following Propoſition.

Prop.

Prop. 2.

A Logarithmical Number being given, to find the Abſolute Number thereunto belonging.

Let it be required to find the Abſolute Number belonging to this Logarithm, 1,20412; look in the Table in the Firſt Page thereof, and caſting your Eye down among the Numbers, under the word *Logar.* you will find this Number 16, to ſtand juſt againſt it, on the Left Hand which is the Abſolute Number of that Logarithm.

The ſame is to be underſtood of all other Numbers compriſed in the foregoing Table.

Obſerving this Caution; when you have a Logarithmical Number given, (which when you look for) you cannot find in the Table, you muſt then take the neareſt Number thereto, and the Abſolute Number which ſtands againſt it, is the neareſt (leſs) whole Number, which you muſt take.

As for Example.

If you have this Logarithmical Number, 0,63258, which if you look for in the

Table, you cannot find it; therefore you must take the neareſt leſs Number which you will find to be 0,60206; and right againſt it (on the Left hand), you will find to be 4, the neareſt Abſolute Number to that Logarithm.

Let this ſuffice for the Deſcription; next follows the Uſe.

The Uſe of the Table of Logarithms in Arithmetick, which ſhall be exemplified in Queſtions of Multiplication, Diviſion, and the Extracting the Square and Cube Roots, being ſuch parts of Arithmetick which tend wholly to the matter intended in this Treatiſe; and therefore I ſhall begin with Multiplication.

Multiplication by the Logarithms.

YOu muſt add the Logarithms of the Two Numbers, (to be Multiplied together,) and the Sum of them will be the Logarithm of the Number produced by that Multiplication.

Example.

Example.

Let it be required to Multiply 48 by 5; First ſet down the Two Numbers to be Multiplied One under another, and to them ſet their reſpective Logarithms, as in the Margin; which being added together, the Sum of them (which is the Logarithm of the Product) being ſought in the Table, the Abſolute Number anſwering thereto is 240, the Product of thoſe Two Numbers Multiplied together.

48	1,68124
5	0,69897
240	2,38021

Diviſion by the Logarithms.

AS Multiplication (by the Logarithms) was performed by Addition, ſo Diviſion is performed by Subtraction: Wherefore to perform Diviſion, you muſt Subtract the Logarithm of the Number, by which you are to Divide from the Logarithm of the Number, which is to be Divided, and the Number which remains ſhall be the Logarithm of the Quotient.

Example.

Let it be required to Divide 228 by 12; First set down the Logarithm of 228, and under it set the Logarithm of 12, and Subtract the Lesser from the Greater, the Remainder is the Logarithm of the Quotient; which being sought in the Table, you will find 19 to be the Answer of the Question, being the Quotient sought: And so many times is 12 contained in 228.

228.	2,35793
12.	1,07918
19.	1,27875

Of a CIRCLE.

1. *The Diameter being given, to find the Circumference by the Logarithms.*

THe Proportion is as 7 to 22, so is the Diameter to the Circumference.

Wherefore to find the Circumference of any Circle, whose Diameter is given,

Add the Logarithm of the Diameter given to the Logarithm of 22, and from the Sum of them Subtract the Logarithm of 7, the Remainder

Remainder ſhall be the Logatithm of the Circumference ſought.

Example.

If the Diameter of a Circle be 113, what is the Circumference?

Firſt ſet down the Logarithm of 22, which is	1,34242
Add the Logarithm of 113 which is	2,05308
from which Subtract the Logarithm of 7, which is	3,39550 0,84510
which being ſought in the Tables is the neareſt Logarithm of 355; and ſo much is the Circumference of a Circle, whoſe Diameter is 113.	2,55040

2. *The Circumference of a Circle being given, to find the Diameter.*

The Proportion is as 22 is to 7; ſo is the Circumference to the Diameter.

Wherefore to the Logarithm of 7, add the Logarithm of the Circumference given, and from the Sum, Subtract the Logarithm of 22, the Remainder ſhall be the Logarithm of the Diameter.

Example.

Example.

If the Circumference of a Circle be 355, what is the Diameter thereof?

First set down the Logarithm of 7. which is—— 0,84510
and to it add the Logarithm of 355 2,55023

from which Subtract the Logarithm of 22—— 3,39533 1,34242
and the Remainder is the neareſt Logarithm of 113, —— 2,05291
which is the Diameter required.

3. *The Diameter of a Circle being given, to find the Area or Superficial Content thereof.*

The Proportion is as 28 is to 22, ſo is the Square of the Diameter to the Area.

Wherefore to the Logarithm of 22, add the Logarithm of the Diameter doubled, and from the Sum ſubtract the Logarithm of 28, the Remainder ſhall be the Logarithm of the Area required.

Example.

If the Diameter of a Circle be 12, what is the Area or Superficial Content thereof?

First,

First ſet down the Logarithm of 22, which is	1,34242
and to that the Logarithm of 12, the given Diameter, ſet down—	1,07918
Twice	1,07918
Add all Three together,	3,50078
from which Subtract the Logarithm of 28,	1,44716
The Remainder is the neareſt Logarithm to the Number 113, and	2,05362

ſome ſmall matter more is the Area of that Circle.

4. *The Circumference of a Circle being given, to find the Area.*

The proportion is as 88 is to 7; ſo is the Square of the Circumference to the Area.

Wherefore to the Logarithm of 7, add the Logarithm of the Circumference Twice, and from the Sum Subtract the Logarithm of 88; the Remainder ſhall be the Logarithm of the Area required.

Example.

Example.

If the Circumference of a Circle be 38, what is the Area thereof?

First set down the Logarithm of 7, which is	0,84510
To which add the Logarithm of the Circumference Twice.	1,57978
	1,57978
The Sum	4,00466
Subtract the Logarithm of 88,	1,94448
the Remainder is the neareſt Logarithm of 115 the Area ſought.	2,06018

CHAP.

CHAP. IV.

CONTAINING

Geometrical Rudiments

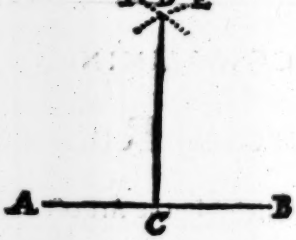
Useful in the Art of

GUNNERY.

How to raise a Perpendicular from the middle of a Line given.

LEt the Line given be A. B. and let C be a Point therein given, from which it is required to raise a Perpendicular. First therefore open the Compasses to any convenient distance; and setting one Foot

Foot in the Point C, with the other ſet off on either ſide thereof the equal diſtances C A, and C B; then opening the Compaſſes to any convenient wider diſtance, ſetting one Foot in the Point A, with the other ſtrike the Occult Arch at F,

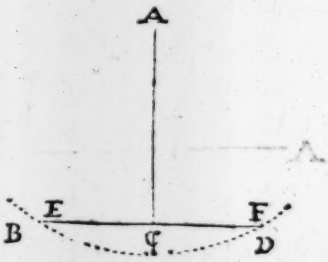


then with the ſame diſtance, ſet one Foot in the Point B, and with the other draw the Arch F, croſſing E in the Point D; from whence draw the Line D C, which Line is a Perpendicular unto the given Line A, B, as was required.

To let a Perpendicular fall from a Point aſſigned, to the middle of a Line given.

Let the Line given whereupon you would have a Perpendicular let fall, be the Line B C D, and the Point A to be the Point aſſigned

ſigned from whence you would have the Perpendicular let fall from the given line B C D; Firſt ſet one Foot of your Compaſſes in the Point A, and opening them to any convenient diſtance, ſo that it be more than the line A C; Deſcribe one Arch of a Circle with the other Foot, ſo that it may cut the line B C D, twice, that is, at E and at F;

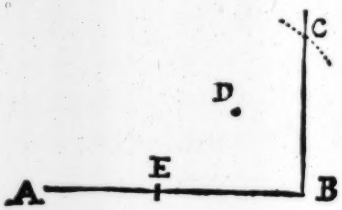


then find the middle between theſe, which will be the Point C; from which Point draw the line at C, which is the Perpendicular which was to be let fall.

To raiſe a Perpendicular upon the end of a Line given.

Suppoſe the line whereupon you would have the Perpendicular raiſed, be the line A B;

A B; firſt open your Compaſſes to a convenient diſtance, and ſet one Foot in the Point B, and let the other Foot fall any where above the line, as at the Point D; and in that Point, let one Foot of your Compaſſes remain, turning the other about until it touch the line A B, in the Point E,

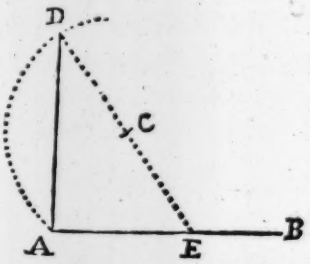


then turn the ſame Foot of the Compaſſes towards C, and draw an Occult Arch, and lay the Edge of a Ruler to thoſe Two Points E and D, and where the ſame edge of the Ruler doth cut the Arch C, from that Point draw the line C B, which ſhall be a Perpendicular at the end of the line A B.

To let fall a Perpendicular from a Point aſſigned, unto the end of a Line given.

Let the line A B be given, unto which it is required to let a Perpendicular fall from the

the assigned point D unto the end A. First, from the assigned point D, draw a line unto any point of the given line A B, which may be the line D C E; then find the middle of the line D E, which is at C, place one foot of your Compasses in that point, and extend the other foot unto D or E, with which distance draw the Semicircle D A E, which shall cut the given line A B, in the point A,

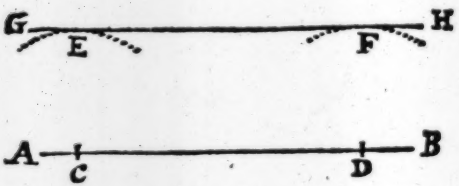


from which point draw the Line D A, which is the Perpendicular let fall from the assigned point D, on the end of the given line A B, as was required.

To draw a Line Parallel to a Line given.

Let A B, be a Line given, whereunto it is required to draw a Parallel. First, set

one Foot of the Compasses in the point C, and opening the other Foot at pleasure, draw the Arch E, then with the same distance set one Foot in the point D, and draw the other Arch F.



Lastly, lay a Rule to the convexities of both those Arches, and draw the line G H, which shall be a Parallel to A B, as was required.

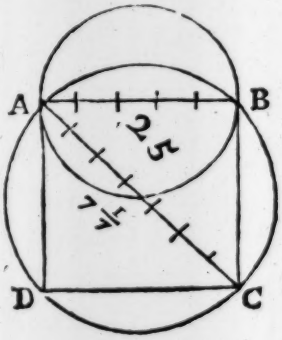
A Geometrical Problem useful in the Art of Gunnery.

A Geometrical way to find the Diameter of any Bullet that weigheth twice as much as a known Bullet.

TAke the Diameter of the lesser Bullet, whose weight you know, and square that Diameter. (*viz.*) Make a Geometrical Square,

Square, each side to be equal to the Diameter of the Bullet given, then draw a Diagonal line from either of the Two opposite Angles, and that Diagonal shall be the Diameter of a Bullet twice the weight of the other; then divide the said Diagonal into Two equal parts, setting one Foot of the Compasses in the midst of that Diagonal, and with the other Foot describe a Circle, and that Circumference will represent a Bullet twice as much weight as the other.

The sight of the Annexed Figure, is a sufficient Explanation.



AB is the Diameter of the lesser Bullet AC, the Diameter of the greater.

Performed by Arithmetick.

Suppoſe the Diameter of the leſſer Bullet be Five Inches, the Square thereof is Twenty Five, the Double of it is Fifty, the Root thereof is 7 $\frac{1}{7}$; and ſo much is the Diameter of the greater Bullet.

The weight of any Shot given, to find the Diameter Geometrically.

Suppoſe a Shot be One, Two or Three Pound weight of Metal, or Stone aſſigned, if one Pound divide the Diameter into Four parts, and Five ſuch parts will make the Diameter of a Shot of the ſaid Metal or Stone, that ſhall weigh juſt Two Pound.

Divide the Diameter of a Shot weighing juſt Two Pound in Seven equal parts, and Eight ſuch parts will make a Diameter of a Shot of Three Pound. And divide the Diameter of a Shot of Three Pound into Ten equal parts, and Eleven ſuch maketh a Shot of Four Pound.

Divide

Divide the Diameter of a Shot of Four Pound into Thirteen parts, Fourteen such parts will make a Diameter for a Shot of Five Pound.

And so dividing each next Diamter into Three equal parts more, the next Lesser was divided into; and it will with one part added from a Diameter of a Shot, that will weigh just one Pound more. So you may proceed infinitely increasing or decreasing, by taking one part less than it is appointed to be divided into.

CHAP. V.

Geometrical Theorems AND PROBLEMS.

Theorem 1.

ALL Circles are equal to that Right Angled Triangle, whose containing sides, the one is equal to the Semidiameter, and the other to the Circumference thereof.

Theorem 2.

The proportion of the Diameter of a Circle to the circumference, is as 1,000000 to 3,141593 fere, or as (*Archim.*) 7 to 22.

Theorem 3.

The proportion of the Diameter to the side of the Square equal to the Circle, is as 1,000000 to 886227 fere.

Theorem 4.

The proportion of the Diameter to the side of the inscribed Square, is as 1,000000 to 707107 fere.

Theorem 5.

The proportion of the Circumference to the Diameter, is as 1 to . 318310 fere; or as 22 to 7.

Theorem 6.

The proportion of the Circumference to the side of the Square equal to the Circle, is as 1 to . 282095.

Theorem 7.

The proportion of the Circumference to the ſide of the inſcribed Square, is as 1 to .225078.

Arithmetical Problems appertaining to the Art of Gunnery, and wrought by Decimal Arithmetick, by the Logarithms, and Gunter's *Scale.*

PROB. 1.

The Diameter of a Circle being given, to find the Circumference.

The Analogy.

AS 1 is to the Diameter, ſo is 3.142 to the Circumference; or as 7 to 22, ſo is the Diameter to the Circumference.

If

If the Diameter of a Circle be 15 *Inches, what is the Circumference by* Gunter's *Scale?*

By the Logarithms.

As the Log. of 15 (the Diameter) 1,17609
is to the Logarithm of 3,142——0,49720
so is the Logarithm of ——————0,00000

to the Logar. of the Answer. 47,13167329

Extend the Compasses (upon the Line of Numbers) from 1 to the Diameter, the same extent will reach from 3.142 to 47.13 the Circumference.

PROB. 2.

The Circumference of a Circle being given, to find the Diameter.

The Analogy.

As 3,142 is to 1, so is the Circumference 47:13 to the Diameter 15 Inches.

If

If the Circumference of a Circle be 47 *Inches, and* 13 *parts of a* 100 (*ſuppoſing every Inch to be divided into* 100 *parts,*) *what is the Diameter? or as* 22 *to* 7, *ſo is the Circumference to the Diameter.*

By the Logarithms.

As the Logarithm of —3,142—0,49720
is to the Logarithm of ——1———0,00000
ſo is the Logarithm of ——47. 13--1,67329

to the Logar. of the Anſwer.———1,67329

15 ——1,17609

By Gunter's *Scale.*

Extend the Compaſſes upon the line of Numbers from 47. 13 the Circumference, the ſame extent, the ſame way ſhall reach from 3,142. to the Diameter 15.

PROB.

PROB. 3.

The Diameter of a Circle being given, to find the side of a Square equal to it.

If the Diameter of a Circle be 15 Inches, what shall be the side of a Square equal to it?

The Analogy.

As 1 is to 15, so this Number 8862 to 13.29 the side of a Square equal in content to that Circle.

By the Logarithms.

As the Logarithm	1	0,00000
is to the Logarithm	15	1,17609
so is the Logarithm of	8862	0,94753
to the Answer	13,29	2,12362

By Gunter's *Scale.*

Extend the Compasses from 1 to 8862, the same extent shall reach from 15 to 13.29.

PROB.

PROB. 4.

The Circumference of a Circle being given, to find the ſide of a Square, equal in content to that Circle.

If the Circumference of a Circle be 47,13, the ſide of a Square equal to it is required.

The Analogy.

As 1 is to 47.13 ſo is this Number 2821, to 13.29 the ſide of the Square required.

By the Logarithms.

As the Logarithm of	1	0,00000
is to the Logarithm of	4713	0,67329
ſo is the Logarithm of	2821	0,45040
to the Anſwer	13,29	1,12369

By Gunter's *Scale.*

Extend the Compaſſes upon the Line of Numbers from 1 to 2812, the ſame extent ſhall reach the ſame way from 47.13 to 13.29 the ſide of the Square required.

PROB.

PROB. 5.

The Diameter of any Spherical body being known, to find the Circumference.

Let the Diameter of a Bullet be 9 Inches, and the Circumference demanded.

The Analogy.

As 1 is to 3,142, so is 9 to 28,28 ferc, the Circumference sought.

By the Logarithms.

The Log. of 3,124 — 0 49720 } Being Added,
and the Log. of 9 Inch. 0,95424 } gives the Log. of 28,28.

1,45144 Log. Required.

By Gunter's *Scale.*

Extend the Compasses from 1 to 9, the same extent shall reach from 3,142 to 28,28 Inches the Circumference required.

PROB.

PROB. 6.

The Circumference of any Spherical body being known, to find the Diameter.

Let the Circumference of a Bullet be 28,28 Inches, and 28 Hundred parts, the Diameter is required.

The Analogy.

AS 3.142 is to 1, ſo is 28,28 to 9 Inches, the Diameter required.

By the Logarithms.

Log. 28.28	145144
Log. 3,142	049720 Subtracted.
	,95424 Log. 9. Required.

By Gunter's *Scale.*

Extend the Compaſſes upon the Line of Numbers from 3,142 to 1, the ſame extent the ſame way ſhall reach from 28.28 to 9 the Diameter required.

PROB.

PROB. 7.

The Diameter and Circumference of any Spherical Body being known, to find the Superficial Content?

Let the Diameter of a Shot be 9 Inches, and the Circumference 28 Inches and 2800 parts of an Inch, how many Square Inches is there contained on the Superficies of that Shot.

The Analogy.

As 1 is to 9 Inches the Diameter, so is 28,28 the Circumference to the Superficies 254,5.

So that there is contained in the Superficies of the same Bullet 254 Inches and an half.

By the Logarithms.

Log. 9.	——	95424
Log. 28,28	—	145144
S. 254,5	12-40568	Log. Required.

By Gunter's *Scale.*

Extend the Compasses from 1, to 28.28 on the Line of Numbers, the same extent the same way shall reach from 9 to 254,5, the Superficial Content required.

Or else by knowing the Diameter, work thus; Extend the Compasses from 1 to 81, the Square of the Diameter, and the same extent will reach from this Number 3,142, to 254,5 the Superficial content as before.

PROB. 8.

The Axis or Diameter of a Globical body being known, to find the Solid Content.

If the Diameter of a Shot be 9 Inches, what is the Solid Content in Square Cubical Inches?

☞ *The Rule for this and the like Questions is this; as the Diameter is to the Cube itself, so is* 11 *to the Solid Content.*

The Analogy.

AS the Diameter 9 is to the Cube thereof 729, so is 11 to the Solid Content in Cubical Inches.

By

By the Logarithms.

As Logar. —— 9 —— 0,95424
is to Logar. —— 729 —— 2,86272
so is Logar. —— 11 —— 1,04139

to the Cubical Content. 3,90411
891 2,94987 Log. found.

By Gunter's *Scale.*

Extend the Compasses from 9 to 11, the same extent shall reach from 729 to 891, the Cubical Inches contained in that Bullet, or the extent from 1 to the Diameter, being thrice repeated from .5238, will reach the Solid Content required.

PROB. 9.

The Diameter of a Bullet being given with the weight, to find the weight of another Bullet of the same Metal, but of another Diameter, either greater or lesser.

Let there be propounded an Iron Bullet of 4 Inches Diameter, weighing 9 Pound, and let the Question be put to know what ano-

ther Bullet (of the ſame Metal) will weigh that is of 8 Inches Diameter.

The Analogy.

AS the Cube of 4 the Firſt Diameter which is 64, is to 9 *l.* ſo is the Cube of 8 the laſt Diameter, which is 512, to 72 *l.* the weight required.

By the Logarithms.

The Rule.

Triple the difference of the Logarithms which belong to the Two Terms, which have the ſame denomination; then if the Firſt Term be leſs than the Second, add that Sum to the Logarithm of the other Term: ſo you ſhall have the Logarithm of the 4*th* Term deſired.

Diameter 4 Inches, Logar.	0,60206
Diameter for 8 Inches, Logar.	0,90309
Difference,	30103
Difference tripled	0,90309
Weight given 9 *l.* Logar.	0,95424
Weight required 72 *l.* Logar.	1,85735

By Gunter's *Scale.*

Extend the Compasses from 4 to 8, the same extent from 9 thrice repeated, will reach to 72, the Answer required.

So if a Bullet of 4 Inches Diameter weigh 4 *l*, a Bullet of 6 Inches Diameter, shall weigh 30 *l*, and a Bullet of 7 Inches Diameter shall weigh 47 $\frac{1}{2}$ *l*, and a Bullet of 3 Inches Diameter, shall weigh 4 *l*.

But here it is necessary to shew what Proportions there are between several Metals used for this purpose; as of Brass, Iron, Lead and Stone, according to the best Approved Authors.

1. The proportion between Lead and Iron, is as 2 to 3; so that a Leaden Bullet of 3 Pound weight, is equal in Diameter with an Iron Bullet of 2 Pound weight.

2. The proportion between Iron and Stone, is as 3 to 8; therefore a Stone of 6 Pound weight is equal in bigness to a piece of Iron of 16 Pound weight.

3. The proportion between Lead and Stone, is as 4 to 1; so that a Bullet of Lead of Eight Pound, and a Stone Bullet of Two Pounds, are equal in Diameter.

4. The proportion between Iron and Braſs, is as 16 to 18; and the proportion between Lead and Braſs, is as 24 to 19.

And here note, that ſome Stone is heavier than other, and ſo likewiſe of Metals, the finer they are, the heavier they be, being of the ſame magnitude.

PROB. 10.

Having the weight of a Bullet of one kind of Metal, to find the weight of a Bullet of another kind of Metal, being equal in magnitude.

Example.

If a Leaden Bullet weigh 106 Pounds, what will a Bullet of Marble weigh?

By the Third Rule aforegoing, it is found that a Bullet of Lead to the Bullet of Stone, bears ſuch proportion as 4 to 1.

The

The Analogy.

As 4 : 1 :: 106 :: 26,5.

Performed by the Logarithms.

The Logarithm of 106 is ——— ,02530
The Logarithm of 4 is ——— ,60206

The Logarithm of 26,5 found--42324

By Gunter's *Scale.*

Extend the Compaſſes upon the Line of Numbers from 4 to 1, the ſame extent from 106 ſhall reach the ſame way to 26,5 the weight of a Stone Bullet that is equal in bigneſs to that Leaden one of 106 Pound.

On the contrary, having the weight of a Stone Bullet, to find the weight of a Leaden Bullet of the ſame magnitude; extend the Compaſſes from 1 to 4, the ſame extent ſhall reach from 26,5 to 106.

PROB. 11.

A Bullet of Iron that weigheth 72 Pound, what will a Bullet of Lead weigh that is equal to it in bigneſs?

The Analogy.

As :2 :: 3 :: 72 :: 108.

By the Logarithms.

Logarithm 2,	30103
Logarithm 3,	,47713
Logarithm 72,	,85733
	1,33476
Logarithm 108,	03343

By Gunter's *Scale.*

Extend the Compaſſes from 2 to 3, on the Line of Numbers, the ſame extent ſhall reach from 72 to 108 the weight ſought.

But if the weight of the Leaden Bullet be given, (*viz.*) 108, then to get the weight of the Iron Bullet.

Extend

Extend the Compasses from 3 to 2, the same extent shall reach from 108 to 72, the weight of the Irom Bullet.

PROB. 12.

The Diameter and Weight of any one Cylinder or Piece of great Ordnance taken at the Base Ring being known, to find the weight of any other piece of the same Metal and Shape, either greater or lesser, its Diameter being only known.

As for Example.

If a Brass Saker whose Diameter is 11,5 *Inches, what will another Piece weigh, whose Diameter is* 8,75 *Inches?*

By Arithmetick.

The Analogy.

As 11,5 is to 1900 :: so is 8,75 to almost 8,37.

By the Logarithms.

As the Log. greateſt Diam.--11,5--306069
The Log. of the leaſt,——8,75--294200

Difference Increaſing——————11869
Multiplyed by——————————3

Produceth this difference————35607
Which being Subtracted from the Logarithm of the weight given, 1900 ——————} 327853

There remains the Log. 837 ——2,92245

By Gunter's *Scale.*

Extend the Compaſſes from 11,5 to 8,75, the ſame diſtance will reach from the weight given, 1900 Pound being thrice repeated to 837 Pound,

If a Piece of Ordnance of 4 Inches Diameter weigh 1600 Pound, what will another Piece weigh, being of the ſame ſhape and metal of 2 Inches Diameter? Anſwer, 200 Pound.

PROB.

PROB. 13.

Having the Diameter and weight of any Piece of great Ordnance of one Metal, to find the weight of another Piece of Ordnance of another Metal that is of the same shape.

In this Problem there will be required a double operation to find out its weight.

Example.

Let there be a Brass Piece of Ordnance of 11,5 Inches Diameter at the Base Ring, weighing 1900 Pound (as before,) and let the Question be to find the weight of an Iron Piece of Ordnance of the same shape; *viz.* 8,75 Inches Diameter.

In this and the like cases, you must in the First place find the weight of the Piece 8,75 Inches Diameter, as in the last Theorem, as if it were a Brass Piece; and having found the weight to be 837 Pound, you must next seek the proportional Numbers, as in Page 116, at the latter end of the Ninth Problem, whose proportion is there found to be as 16 to 18, which is the proportion between Brass

Braſs and Iron, Braſs being the heavier Metal.

Therefore having found the weight,

The Analogy is

AS 18 is to 16, ſo is 837 to 744.

By the Logarithms.

Log. of 18	1,25527
Log. of 16	1,20412
	,92272
Sum	,12684
Log. found, 744	,87157

By Gunter's *Scale.*

Extend the Compaſſes from 18 to 16, the ſame extent, the ſame way ſhall reach from 837 to 744.

PROB.

PROB. 14.

To find the Superficial Content of the Convex face of any Piece of Ordnance, and also of the Solid Content of the Concavity thereof.

Suppose the Circumference of the Concavity be 22 Inches, and the length of it 12 Foot, or 144 Inches, the Question is, what is the Superficial Content of the Convex face, or what the Solid Content of the Concave Bore.

For the Superficies the Analogy is,

As 1 : 22 :: 144 : 3168, Square Inches.

By the Logarithms.

Logarithm—	22———	,3,1242
Logarithm—	144———	,15836
Logar. found,	3168———	,50078

By

By Gunter's *Scale.*

Extend the Compaſſes from 1 to 22, on the Line of Numbers, the ſame extent, the ſame way ſhall reach from 144, to 3168, the Square Inches required.

To find the Solid Content.

Firſt get the Semidiameter, which in this Example is 3,5 Inches, and alſo the Semicumference, which here is 11, theſe being had,

The Analogy is thus;

As 1 is to 3.5 :: 11 : 38,5.

So many Square Inches are contained in the Baſe or Plain of the Concavity of the Mouth.

By the Logarithms.

Logarithm	35	54407
Logarithm	11	04139
Logarithm	38,5	58546

By

By Gunter's *Scale.*

Extend the Compasses from 1 to 3,5 the Diameter of the Concave assumed, the same extent will reach the same way from 11 to 38,5, the Base of the Cylinder required.

The Base of the Cylinder being thus found, to find the Solidity of the Cylinder.

The Analogy.

As 1 is to 38,5 (the Area of the Base of the Cylinder,) so is the length of the Cylinder 144 Inches to 5544 Cubical Inches.

By the Logarithms.

Logarithm—	385 ———	,58546
Logarithm—	144 ———	,15836
Logarithm—	5544 ———	,74382

By Gunter's *Scale.*

Extend the Compasses on the Line of Numbers, from 1 to 38,5, the same extent, the same way shall reach from 144 to 5544.

PROB.

PROB. 15.

To know how much of every kind of Metal is contained in any Braſs Piece of Ordnance.

If the proportions of Metals uſed by Gunfounders is ſuppoſed to be thus, that for every 100 Pound of Copper, to put in 10 Pound of Braſs, and 8 Pound of Pure Tin; now ſuppoſing this Mixture to be true, let it be required how much of every ſort of theſe Metals is in a Gun of 5600 Pound weight.

For Anſwer to this and the like Queſtions, firſt joyn all the ſeveral mixtures together, that 100, 10, and 8, and this muſt be the Firſt Number in the Rule of Proportion; the weight of the Piece, the Second Number, which here is 5600; and the Third Number is each ſeveral ſort of Metal in the mixture, which is here 100, 10, and 8.

The

The Operation.

The Sum of the common Mixtures are 118.

And then the Analogies are thus,

As 118 is to 5600,

			100 *Copper*,	
			10 *Latten*,	
			8 *Tin*.	
So is	100	4745,7	*Copper*,	118
	10	474,6	*Brass*,	
	8	379,7	*Tin*.	

Analogy for the Copper is,

As 118 to 5600, so is 100 to 4745,7 Copper.

Analogy for Brass.

As 118 to 5600, so is 10 to 474,6 *fere*, Brass.

Analogy

Analogy for Tin.

As 118 to 5600, so is 8 to 379,7 *for* Tin.

4745,7	Which Three Sums thus
474,6	found, being added toge-
379,7	ther, they make, the just
56000	weight of the piece pro-
	pounded.

By the Logarithms.

The Proportions are thus wrought.

For the Copper.

Logarithm— 118 ——	071882
Logarithm—5600 ——	748188
Logarithm— 100 ——	000000
	748188
Log. found,474,57 ——	676306

Here you are referred to a larger Table of Logarithms, than is in this Book, for this operation and the next following.

For

For Brass.

Logarithm	118	071882
Logarithm	5600	748188
Logarithm	10	000000
		748188
Logarithm found, 474,6		676306

For Tin.

Logarithm	118	071882
Logarithm	5600	748188
Logarithm	8	903090
		651278
Logarithm	379,7	579396

By Gunter's *Scale.*

For the First Operation for Copper.

Extend the Compasses from 118 (upon the Line of Numbers) to 5600, the same

extent, the ſame way, ſhall reach from 100 to 4745,7.

For Braſs.

Extend the Compaſſes from 118 to 5600, the ſame extent ſhall reach from 10, to 4746, being one place leſs than the former.

For Tin.

Extend the Compaſſes from 118 to 5600, the ſame Extent, the ſame way ſhall reach from 8 to 379,7.

PROB. 16.

By knowing what quantity of Powder will load ſome one Piece of Ordnance, to find how much of the ſame Powder will load any other Piece of Ordnance, Greater or Leſſer.

Example.

If a Saker of 3,75 Inches Diameter in the Bore requires Four Pound of Powder for its Load, what will a Demy Cannon of 6,5 Inches Diameter in the Bore require?

The Analogy.

As 4,75 is to 4, so is 6,5 to 20 ⅔ *fere.*

☞ *But note, that it is here understood, that the Demy-Cannon ought to be as well Fortified as the Saker is; (viz.) it should bear the same proportion to the Saker, both in weight and thickness of Metal that the Bore thereof beareth to the Saker; for the Demy-Cannon in this Example, ought to be* 8351 *Pounds, which would be of a Proportion to the Saker, to carry a proportional weight of Powder.*

But if the Demy-Cannon be found to want of its proportional weight with the Saker, as if it weigh but 6000 Pounds, then to find its due load in Powder answerable to its strength and weight of Metal,

Multiply the weight thereof 6000 by 20,8 the Charge already calculated, and divide the Product by 8351, the weight it ought to have had, and the Quotient is 14,9; therefore 14,9 Pounds is a sufficient Charge for such a Gun.

A Table of the weight of Iron Shot in Pounds and Ounces, from One Inch Diameter, to Ten Inches, to every Eighth part of an Inch.

Shot.	lb.	oz.	Shot.	lb.	oz.	Shot.	lb.	oz.
I	00	02	1	09	13	1	50	13
1	00	03	2	10	12	2	53	09
2	00	04	3	11	12	3	56	06
3	00	05	4	12	13	4	59	05
4	00	07	5	13	14	5	62	05
5	00	09	6	15	01	6	65	07
6	00	12	7	16	04	7	68	10
7	00	14	V	17	09	VIII	72	00
II	01	02	1	18	14	1	75	06
1	01	05	2	20	05	2	78	15
2	01	09	3	21	13	3	82	09
3	01	14	4	23	06	4	86	05
4	02	03	5	25	00	5	90	03
[illegible]	02	08	6	26	11	6	94	03
[illegible]	[illegible]	[illegible]	7	28	08	7	98	04
[illegible]	[illegible]	[illegible]	VI	30	08	IX	102	08
[illegible]	[illegible]	[illegible]	1	32	05	1	106	13
[illegible]	[illegible]	[illegible]	2	34	05	2	111	04
[illegible]	[illegible]	[illegible]	3	36	06	3	115	13
[illegible]	[illegible]	[illegible]	4	38	09	4	120	09
[illegible]	[illegible]	[illegible]	5	40	14	5	125	05
[illegible]	06	11	6	43	04	6	130	05
[illegible]	07	06	7	45	11	7	135	06
[illegible]	08	02	VII	48	03	X	140	04
[illegible]	09	00						

The

The foregoing Table was Calculated from the Directions in this Chap. Prob. 9. page 113.

One Example will ſhew the uſe of this Table.

Example.

I require the weight of a Shot whoſe Diameter is 6 $\frac{1}{2}$.

Look for 6 Inches $\frac{1}{2}$ in the Column under Title Shot, and right againſt it in the Columns under Title *lb.* and *oz.* you will find 45 *lb.* and Eleven Ounces, the weight required.

A Table shewing the height and weight of Iron, Lead and Stone shot, according to their Diameters in Inches and Quarters, and their respective weights in Pounds and Ounces.

Inches.	Quarters.	Iron. Pounds.	Iron. Ounces.	Lead. Pounds.	Lead. Ounces.	Stone. Pounds.	Stone. Ounces.
1	0	[illegible]	0	0	3	0	1
1	1	[illegible]	0	0	6	0	3
1	2	[illegible]	0	0	9	0	4
1	3	1	0	0	13	0	5
2	0	1	1	1	11	0	7
2	1	1	9	2	0	0	9
2	2	2	2	3	0	0	12
2	3	2	14	4	3	1	0
3	0	3	12	5	0	1	4
3	1	4	12	6	9	1	8
3	2	6	1	8	11	2	9
3	3	7	5	9	14	2	7

Inches

Inches.	Quarters.	Iron. Pounds.	Iron. Ounces.	Lead. Pounds.	Lead. Ounces.	Stone. Pounds.	Stone. Ounces.
4	0	8	15	11	5	2	13
4	1	10	10	15	15	3	10
4	2	12	10	17	15	4	3
4	3	14	14	21	5	5	9
5	0	17	5	24	12	6	3
5	1	20	1	30	0	7	8
5	2	23	2	35	10	8	14
5	3	26	6	39	9	10	10
6	0	30	0	45	0	11	4
6	1	34	0	51	0	12	12
6	2	38	0	57	0	14	3
6	3	42	0	63	0	15	12
7	0	48	0	72	0	17	10
7	1	53	0	79	0	19	14
7	2	58	0	87	0	24	12
7	3	64	0	96	0	24	0
8	0	72	10	106		26	04
8	1	78	0	117		28	08
8	2	87	3	130		34	08
8	3	95	0	142		35	10

Inches.	Quarters.	Iron. Pounds.	Iron. Ounces.	Lead. Pounds.	Lead. Ounces.	Stone. Pounds.	Stone. Ounces.
9	0	101	0	150		37	10
9	1	109	6	161		40	4
9	2	121	10	181		44	2
9	3	132	11	198		49	8
10	0	138	0	207		51	10
10	2	164	2	246		60	0
11	0	184	0	275		69	8
11	2	216	0	324		81	0
12	0	240	0	360		90	0
13	0	305	0	451		114	0
14	0	389	2	583		146	8

One Example will ſhew the uſe of this Table.

A Shot is 7 Inches ½ Diameter, which Number ſeek in the Firſt Column; in the next, you have the weight of the Iron Shot, 64 Pound; and in the Third Column, you find the Leaden Shot to weigh 96 Pound; and in the 4*th* Column, the weight of the Stone Shot to be 24 Pound.

A

A General Table of Gunnery shewing the Length and Weight of most of our English *Ordnance, the Diameter of their Bore, the weight of their Shot, the Ladles length, and their weight of Powder to Charge them.*

Names of the Pieces of Ordnance.	*Diameter of the Bore.*		*Length of the Piece.*		*Weight of the Piece in Pounds.*	*Breadth of the Ladle.*		*Length of the Ladle.*	
	Inches.	*Parts.*	*Feet.*	*Inches.*	*Pounds*	*Inches.*	*Parts.*	*Inches.*	*Parts.*
Base.	1	2	4	6	200	2	0	4	0
Rabanet.	1	4	5	6	300	2	4	4	1
Falconets.	2	2	6	0	400	4	0	7	4
Falcon.	2	6	7	0	750	4	4	8	2
Minion Ordinary	3	0	7	0	800	5	0	8	4
Minion Large.	3	2	8	0	1000	5	0	9	0
Saker Lowest.	3	4	8	0	1400	6	4	9	6
Saker Ordinary.	3	6	9	0	1500	6	6	10	4
Saker Eldest.	4	0	10	0	1800	7	2	11	0
Demy-Culv. Low.	4	2	10	0	2000	8	0	12	0

Names

Names of the Pieces of Ordnance.	*Weight of Powder.*		*Diameter of the Shot.*		*Weight of the Shot.*		*Piece Shoots point blank.*
	Pounds	*Ounces*	*Inches.*	*Parts.*	*Pounds*	*Ounces*	*Paces.*
Base.	0	8	1	1	0	3	60
Rabanet.	0	12	1	3	0	5	70
Falconets.	1	4	2	2	1	9	90
Falcon.	2	4	2	5	2	8	120
Minion Ordinary.	2	8	2	7	3	5	120
Minion Large.	3	4	3	0	3	12	125
Saker Lowest.	3	6	3	2	4	13	150
Saker Ordinary.	4	0	3	4	6	0	160
Saker Eldest.	5	0	3	6	7	6	163
Demy-Culv. Low.	6	4	4	0	9	0	174

Names

Names of the Pieces of Ordnance.	*Diameter of the Bore.*		*Length of the Piece.*		*Weight of the Piece in Pounds.*	*Breadth of the Ladle.*		*Length of the Ladle.*	
	Inches.	*Parts.*	*Feet.*	*Inches.*	*Pounds*	*Inches.*	*Parts.*	*Inches.*	*Parts.*
Demy-Culv. Ord.	4	4	11	0	2700	8	0	12	6
Demy-Culv. Eld.	4	6	11	0	3000	8	4	13	4
Culverins Beſt.	5	0	11	0	4000	9	0	14	2
Culv. Ordinary.	5	2	11	0	4500	9	4	16	0
Culv. Largeſt.	5	4	11	0	4800	10	0	16	0
Demy-Can. Low.	6	2	11	0	5400	10	4	20	0
Demy Can. Ord.	6	4	12	0	5600	12	0	22	0
Demy Can. Lar.	6	6	12	0	6000	12	0	22	0
Cannon-Royal.	8	0	12	0	8000	14	0	24	0

Four Dutch Pieces.

A 3 Founder.	2	94	11	0	750	5	5	18	0
A 6 Pounder.	3	70	10	0	1500	6	5	14	0
A 12 Pounder.	4	61	9	0	3000	9	0	10	6
A 24 Pounder.	5	79	7	0	5000	11	0	9	0

Names

Names of the Pieces of Ordnance	*Weight of Powder.*		*Diameter of the Shot.*		*Weight of the Shot.*		*Piece Shoots point blank.*
	Pounds	*Ounces*	*Inches.*	*Parts.*	*Pounds*	*Ounces*	*Paces.*
Demy-Culv. Ord	7	4	4	2	10	12	175
Demy-Culv. Eld.	8	8	4	4	12	13	178
Culverins Beſt.	10	0	4	6	15	1	180
Culv. Ordinary.	11	6	5	0	17	9	181
Culv. Largeſt.	11	8	5	2	20	5	183
Demy-Can. Low.	14	0	6	0	30	8	156
Demy-Can. Ord.	17	8	6	1	32	5	162
Demy-Can. Lar.	18	0	6	5	40	14	180
Cannon-Royal.	32	8	7	4	59	5	185

Four Dutch Pieces.

A 3 Pounder.	10	8	5	56	24	0	120
A 6 Pounder.	6	0	4	40	12	0	160
A 12 Pounder.	3	8	3	49	6	0	178
A 24 Pounder.	1	10	2	77	3	0	189

One

One Example of the uſe of the foregoing Table is ſufficient, which ſhall be of the Saker Ordinary, where you will find the Diameter of the Bore to be 3 Inches and ¼ of an Inch, the length of the Piece to be 9 Foot, the weight of the Piece 1500 Pound the breadth of the Ladle to be 6 Inches ⅝ of an Inch, and the length of the Ladle to be 10 Inches and ⅝, of which is half an Inch, and the weight of Powder to Charge that Piece is 4 Pounds, the Diameter of the Shot to be 3 Inches ¼, which is 3 Inches and ¼, the weight of the Shot to be 6 Pound, and that the Piece ſhoots point blank 160 Geometrical Paces.

CHAP.

Names of the Pieces of Ordnance	*Weight of Powder.*		*Diameter of the Shot.*		*Weight of the Shot.*		*Piece Shoots point blank.*
	Pounds	*Ounces*	*Inches.*	*Parts.*	*Pounds*	*Ounces*	*Paces.*
Demy-Culv. Ord	7	4	4	2	10	12	175
Demy-Culv. Eld.	8	8	4	4	12	13	178
Culverins Beſt.	10	0	4	6	15	1	180
Culv. Ordinary.	11	6	5	0	17	9	181
Culv. Largeſt.	11	8	5	2	20	5	183
Demy-Can. Low.	14	0	6	0	30	8	156
Demy-Can. Ord.	17	8	6	1	32	5	162
Demy-Can. Lar.	18	0	6	5	40	14	180
Cannon-Royal.	32	8	7	4	59	5	185

Four Dutch Pieces.

A 3 Pounder.	1	10	2	77	3	0	120
A 6 Pounder.	3	8	3	49	6	0	160
A 12 Pounder.	6	0	4	40	12	0	178
A 24 Pounder.	10	8	5	56	24	0	189

One

One Example of the uſe of the foregoing Table is ſufficient, which ſhall be of the Saker Ordinary, where you will find the Diameter of the Bore to be 3 Inches and $\frac{1}{4}$ of an Inch, the length of the Piece to be 9 Foot, the weight of the Piece 1500 Pound the breadth of the Ladle to be 6 Inches $\frac{5}{8}$ of an Inch, and the length of the Ladle to be 10 Inches and $\frac{1}{2}$, of which is half an Inch, and the weight of Powder to Charge that Piece is 4 Pounds, the Diameter of the Shot to be 3 Inches $\frac{1}{4}$, which is 3 Inches and $\frac{1}{4}$, the weight of the Shot to be 6 Pound, and that the Piece ſhoots point blank 160 Geometrical Paces.

CHAP.

CHAP. VI.

Of the Different Fortifications of most Pieces of Ordnance.

THere are Three Degrees used in Fortifying each sort of Ordnance, both Cannons and Culverings.

First, Such as are ordinarily Fortified are called *Legitimate Pieces.*

Secondly, Such whose Fortification is lessened, are therefore called *Bastara Pieces.*

Thirdly, Those that are Extraordinary Pieces, are called *Double Fortified.*

The Fortification is reckoned by the thickness of the Metal at the Touch-hole, at the Trunnions, and at the Muzzle, in proportion to the Diameter of the Bore.

The Cannons double Fortified, have full one Diameter of the Bore, in thickness of Metal

Metal at the Touch-hole, and $\frac{11}{16}$ at the Trunnions, and in their Muzzle $\frac{7}{16}$.

The Leſſened Cannons have at their Touch-hole $\frac{3}{4}$ or $\frac{12}{16}$ of the Diameter of their Bore, in thickneſs of Metal, and $\frac{11}{16}$ at the Trunnions, and $\frac{5}{16}$ at the Muzzle.

The Ordinary Fortified Cannons have $\frac{7}{8}$ at the Touch-hole, $\frac{5}{8}$ at the Trunnions, and $\frac{1}{2}$ at the Muzzle.

All the Double Fortified Culverings, and all Leſſer Pieces of that kind, have 1 Diameter, and $\frac{1}{2}$ at the Touch-hole, $\frac{11}{16}$ at the Trunnions, and $\frac{5}{16}$ at the Muzzle.

The Ordinnary Fortified Culverings are Fortified every way as your Double Fortified Cannons; and the Leſſened Culverings as the Ordinary Cannons in all points.

CHAP.

CHAP. VII.

How much Powder is fit for Proof, and what for Action for any Piece of Ordnance.

FOR Cannons ⅓ of the weight of the Iron Shot for Proof, but for Service, half the weight of the Shot is enough, especially for Iron Ordnance, which will not endure so much Powder as Brass Guns by one quarter.

For Culverings their whole weight of their Shot for proof, and for Service ⅔, for the Saker and Falcon ¼ of the weight of their Shot.

And for Lesser Pieces, the whole weight of the Shot may be used in Service, till they grow hot, for then you must abate by discretion.

For

For proof theſe Leſſer Pieces, you may take one, and ; of the weight of the Shot, therein alſo muſt be reſpect had to the ſtrength and goodneſs of the Powder, which is to be ordinary Corn Powder.

To make Ladles to Load your Guns with.

THe Ladles ought to be ſo proportioned for every Gun, that Two Ladles full of Powder may Charge the Piece; which in General Terms is thus.

The breadth of all Ladles are to be Two Diameters of the Shot, that ſo a Third may be left open for the Powder to fall freely out of the Ladle, when you turn it bottom upwards; the length of the Ladles muſt be ſomewhat different, according as the Piece is Fortified.

For Double Fortified Cannons, the length of the Ladle may be Two Diameters and One half of their Shot, beſides ſo much as is neceſſary to faſten it to the Head of the Ladle-Staff, which will require One Diameter more of Plate; (but this is not reckoned to the length of the Ladle, becauſe it holds no Powder. For Ordinary Can-

nons the Ladle must not exceed Two Diameters of their Shot in length.

For Culverings and Demy-Culverings, the Ladle may be Three Diameters of their Shot, and Three and a half for Lesser Guns to load them at Twice.

If you would load them at once, you must double the length of the Ladle.

☞ *Observe this for a General Rule, that a Ladle Nine Balls in length, and Two Balls in breadth, will hold the just weight of the Shot in Powder.*

But note, that Iron Ordnance must have but Three Quarters of the Charge of Brass Ordnance.

CHAP.

CHAP. VIII.

To know what Bullet is fit to be used for any Gun.

IT is convenient that the Bullet be somewhat less than the Bore of the Gun; that it may have vent in the Discharge, and not stick and break the Piece.

Now some think one Quarter of an Inch less than the Bore, will serve for all Guns, but this vent is too little for a Cannon, and too much for a Falcon.

It is more Rational and Artificial to divide the Bore of the Gun into Twenty equal parts, and let the Diameter of the Bullet be Nineteen of those parts, according to which proportion the Table aforegoing, in page 137 is Calculated.

To make Cartridges, Moulds and Formers for any ſort of Ordnance.

THe matter of which Cartridges a made, are either Canvas or Paper Royal, either of which being prepared, take the height of the Bore of the Piece, and let the piece of Cloth or Paper be Three times the Diameter of the Bore or Chamber of the Piece for the Breadth, and for the length according as your Piece is; (that is to ſay,) for the Cannon the length of the Cartridge muſt be Three Diameters, in the length for Culverins, Saker, Falcons, *&c.* Four Diameters, leaving at the top or bottom one Diameter more for the bottom of the Cartridge, cutting each ſide ſomewhat larger for the ſewing and glewing them together, having a due reſpect for the augmenting or diminiſhing of your Powder, according to the goodneſs or badneſs thereof, and to the extraordinary over-heating of your Piece; and according to what you are to have your Cartridges made, you muſt have a Former of Wood turned to the height of the Shot, and a convenient length longer than the Cartridge

tridge; before you paſte or glew your Paper on the former, firſt tallow it, ſo will the Canvaſs or Paper ſlip off without ſtarting or tearing; if you make Cartridges for Taper-bored Guns, your former muſt be accordingly tapered; if you make your Cartridges of Canvaſs, allow one Inch for the Seams, but of Paper $\frac{1}{2}$ of an Inch, more than your 3 Diameters for paſting; when your Cartridges are upon the former, having a bottom ready fitted, you muſt paſt the bottom cloſe and hard round about, then let them be well dryed, and mark every one with black or red Lead, or Ink, how high they ought to be filled: And if you have no Scales nor Weights, theſe Diameters of Bullets make a reaſonable Charge; for the Cannon two and a quarter, for the Culvering 3, and for the Saker 3 and a half, for the leſſer Pieces 3 and a quarter of the Diameter of the Bullet, and let ſome want of their weight againſt the time they are over-hot, or elſe you endanger your ſelf and others.

CHAP. IX.

Containing certain

THEOREMS IN GUNNERY.

THEOREM I.

THere are Three material cauſes of the greater violence of any Shot made out of a great Gun, *viz.* the Powder, the Piece, and the weight of the Bullet.

THEOREM II.

Powder is compounded of Three Principles or Elements, Salt-Petre, Sulphur and Coal, whereof it is that which cauſeth the greater violence.

THEOREM III.

Although Salt-Petre be indeed the only and moſt material cauſe of the violence, and that Powder is made more forcible, wherein is the greater quantity of Petre; and of thoſe forementioned Ingredients, there is a certain proportion to be uſed, as to render it the moſt fit for Service upon ſeveral conſiderations; of which more hereafter.

THEOREM IV.

Although Powder is the principal and efficient cauſe of the Force and violence of any Shot, yet ſuch due conſideration ought to be had to the proportions therein uſed in the Art of Gunnery, as giving more or leſs than the due proportion, it may diminiſh the force of the Shot.

THEOREM V.

There is ſuch a convenient weight to be found of the Bullet, in reſpect of the Powder and Piece, as the Bullets Metals being heavier or lighter than that weight, ſhall rather hinder than farther the violence of the range of the Shot.

THEOREM VI.

There is ſuch a convenient Proportion to be found for the Length of every Piece to its Bore, or the Diameter of the Bullet, in reſpect of the Powder and weight of the Ball; as either increaſing or diminiſhing that Proportion, it ſhall abate or hinder the violence of the Shot.

THEOREM VII.

Beſides theſe three moſt material Cauſes of violence, the ſeveral Randoms or different Mountures of Pieces will cauſe a great Alteration, not only in the far ſhooting of all Pieces, but alſo of their violent Battery.

THE-

THEOREM VIII.

Beſides theſe aforementioned, there are many other accidental Alterations which may happen, (eſpecially at Sea,) ſometimes by reaſon of the Wind, the Rarity or Condenſation of the Air, the heating or cooling of the Piece; The different charging by ramming the Powder faſt or looſe, by cloſe or looſe lying of the Bullet; By the unequal recoil of the Piece, or by reaſon of the Ship being upon a Tack, and the Gun ſtanding on the wind-ward or Lee-ward ſide of the Ship, or by the uneven lying of the Piece in the Carriage, with divers ſuch like Accidents, whereof no certain Rules can be preſcribed to reduce thoſe uncertain Differences to any certain Proportions: but all theſe by Practice, Experience and a good judgment are to be performed.

THEOREM IX.

Any Piece being mounted 90 degrees above the Horizon directly to the Zenith, the violent Motion, (being in that ſituation directly oppoſite to the Natural) carries the Bullet in a perfect right-line directly upward, till the form of the violence is

is ſpent, and the natural Motion gotten the victory; then doth the Bullet return down again by the ſame perpendicular Line.

THEOREM X.

But if any Piece is diſcharged upon any Angle of Mounture; although the violent Motion contend to carry the Bullet directly by the Diagonal Line, yet as the natural Motion prevails, it conſtrains it to a Curvity; and in theſe two Motions is made that mixt Compouud or Helical Curvity. And here note, that although the laſt declining Line of the Bullets Circuit ſeemeth to approach ſomewhat to the Nature of a right Line; yet it is indeed Helical, and mixt ſo long as there remaineth any part of the violent motion; but after that is ſpent, then his motion is abſolutely perpendicular to the Horizon.

From whence may be collected this Corrolary, That any Piece being mounted to any degree of Random, ſhall make the Horizontal range proportional to the Degree of Elevation, of which you have a Reſemblance in the Annexed Scheme, Plate I.

Any Piece therefore diſcharged at any Mounture or Random, firſt throweth forth her

her Bullet directly to a certain distance, called the Point-blank Range, and then afterward maketh a Curve, or declining Arch, and lastly finisheth in a direct Line, or nigh inclining towards it; therefore the farther any Piece shooteth in her direct Line (commonly called Point-blank) the more force she hath in the Execution; and the more ponderous the Bullet is, the more it shaketh in battery, although it pierceth not so deep.

THEOREM XI.

The utmost Random of any Piece of Ordnance, is generally judged to be at 45 Degrees of Elevation; and if you mount your Piece to a greater Angle, the Random of the Bullet will be shorter; and to know the right Range of most Pieces, you may see in this annexed Table, as the Title may inform you, where you may see the Horizontal Range or Point-blank, and the utmost Random of each respective Piece, the latter being commonly ten times the distance of the right Ranges.

And

And for the Right Ranges and Random to several Degrees of Mounture, you may note these ensuing Tables, which is measured by Paces, 5 Foot to a Pace.

A Table of Right Ranges or Point-blanks at several Degrees of Mounture.

The Degrees of Mounture.	Right Ranges.
0	19
1	209
2	227
3	244
4	261
5	278
6	285
7	302
8	320
9	337
10	354
20	454
30	693
40	855
50	1000
60	1140
70	1220
80	1300
90	1350

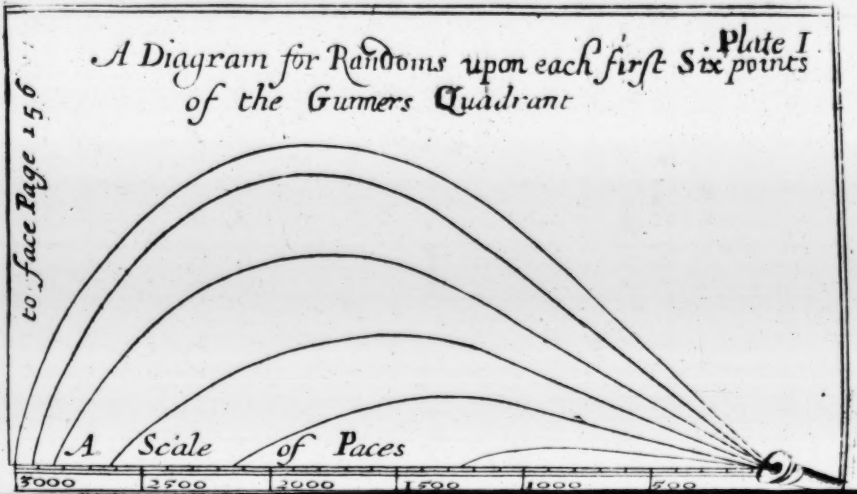
A Table of Randoms at several Degrees of Mounture.

The Degrees of Mounture.	Right Randons.
0	192
1	289
2	404
3	510
4	61[illegible]
5	712
6	828
7	934
8	1044
9	1129
10	1214
20	1917
30	2185
40	2289
50	2283
60	1792
70	1214
80	1000
90	0000

CHAP.

Plate I

A Diagram for Randoms upon each first Six points of the Gunners Quadrant



CHAP. X.

Neceſſary Inſtructions for a Sea-Gunner.

1. THE Firſt thing is, that when a Gunner cometh into a new Ship, that he diligently and carefully meaſure his Guns, to know they are full fortified, be reinforced or leſſened in Metal.

2. Then he muſt with a Ladle and Spunge, draw and make clean all his Guns within, that there may be no old Powder, Stones, Iron, or any thing that may do harm.

3. That he ſearch all the Guns within, to ſee if they are taper Chamber'd, or true bored, or whether they be Crack'd, Flaw'd, or Honey-comb'd within; and finding what Ball ſhe ſhoots, to mark the Weight of the Ball over the Port; that thereby he may ſee

ſee the Mark or Number upon the Carriage and Caſe; ſo that in time of ſervice they may not go wrong.

4. The Guns being dimenſioned and clean as aforeſaid, take half a Ladle of Powder for every Gnn, and blow them off, ſpunge them well; and finding them clean, you may load them with their reſpective Cartridges and Powder, they being ramm'd home with a ſtrait Wadd after it.

Then let the Ball role home to the Wadd, and ſet a Wadd cloſe home to the Ball, that the Ball may not roul out with the motion and tumbling of the Ship.

Then muſt you Tomkin that Piece at the Muzzle, with a wooden Tomkin, which you muſt tallow round about, to preſerve the Powder from wetting.

Likewiſe make a little Tapon of Ockam for the Touch-hole, which muſt be tallowed alſo, to prevent any wet coming to the Powder that way; then let your leaden Apron be put over it; then make your Piece faſt, as occaſion preſents.

5. The Piece being loaded and faſt, then provide to every Piece 24 Cartridges at leaſt, ready made; that is to ſay, 12 fill'd, and 12 empty.

Likewiſe you muſt be careful, ſo long as the Gunner's Crew are buſie with the Powder,

der, that there be no burning Match or Fire in the Ship; Alſo to lay his Cartridges in Barrels or Cheſts, that when there is occaſion to uſe them, they may be without abuſe.

6. The Gunner muſt ſee that he ſorts his Ball very well, and lay every ſort by themſelves in ſeveral Caſes; and upon every Caſe ſet the Weight of one of the Shot, which is in them.

Alſo you ought to make the Bags for Hail for the Guns above, and fill them with Stones, ſmall Shot, or Pieces of old Iron, which may be a great annoyance to the Enemies Men.

7. If it falls out that any new Ports muſt be cut out in the Ship, you muſt be careful that it be made over a Beam, or as near one as poſſible you can; Alſo that they be not higher or lower than the Ports before; likewiſe that there be room for the Guns to play, becauſe if one Gun be diſmounted, there might be another brought to her place: And obſerve that the Carriage ſtand on her Trucks. The uppermoſt part of the Carriage muſt ſtand in the middle of the Port, up and down, that a Man may lay his Piece as you pleaſe.

8. You muſt be careful that the Powder in the Powder-Room be well covered with

with Hides: And alſo that the Ropes, Rammers, and Spunges be ready at hand. And you muſt not let the Powder be unturned above a Month, becauſe the Salt-Petre will be apt to ſink to the lower part of the Barrel, which would be dangerous to make uſe of that Powder; And you muſt every Month draw your Guns; if you think they have got any wetneſs or moiſture in the Powder; Alſo for fear of the Salt Petre diſſolving, which may prejudice the Piece. You muſt alſo be careful of the Candle and Fire about the Gun Room, and eſpecially the Powder Room, that there may come no diſaſter.

Likewiſe a Gunner muſt keep a good Account of all Materials that belong to the Guns, as Ball, Match, and Powder. What part thereof he ſpends, alſo what remains.

9. A Gunner muſt uſe all diligence before they engage with an Enemy, to ſet a Barrel of Water betwixt every two Guns, that when they have conveniency they may dip the Spunges for the cooling of the Guns, and for fear of Fire remaining in the Piece, which may do hurt.

10. Alſo you muſt be ſure that there be no melted Fire-works done in the Ship, but aſhore; for it is dangerous, and a great hazard to the Ship, and Goods; and Men's Lives may thereby be deſtroyed. Alſo

Alſo that in time of ſervice, no Fire-works be brought up in the Round-houſe, or great Cabbin, to ſtand, for fear of Shot coming from the Enemy may fire it, and ſo deſtroy the Ship. But rather to have them kept below in the Powder-Room, or Steward-Room, to prevent Danger.

11. Neceſſaries that a Gunner ought to have for his Ordnance, and the quantity thereof according to the Length of the Voyage, the Quantity and Quality of his Guns.

Alſo if you go in a Man of War, or a Merchant-man, then there is difference of Proviſions; only I will here name them all that belong to a Sea Gunner, that he may take ſuch a Proportion of each, as the occuſion may require, and at the End of the Voyage to give an Account what Stores are ſpent, and what there is yet remaining.

Gunners Stores.

Powder and Match.
Round-ſhot of every ſort.
Double-headed Shot.
Cut Iron of a Foot, or a Foot and a half long.

Wooden Tomkins for each ſort of Gun.

Cartridge-Paper and Glew.

Threed, Needles, Twine and Starch.

Mallets, Handſpikes, Rammer heads.

Worms, Ladles, Spunge-heads, & Spunge-ſtaves, Beds and Quoins of ſeveral ſorts.

Old Shrouds for Breeching, and twice lay'd Stuff for Tackles.

Laſhers, double and ſingle Blocks, new Rope for double Tackles.

Some old Shrouds for Spunges, ſome Lines, Marline, Tarr'd Twine, Port-Ropes.

Moulds for Cartridges for each ſort of Gun, Axle-Trees and Trucks.

Pouch-Barrels and Linſtocks, Crows, Splice-Irons, Primes, Staples and Rings, Tackle-Hooks, Nails, Thimbles, Port-Bands, Sheet-Lead and Leaden-ſhot, old Canvaſs, Scales and Weights.

Lanthorns, Muſcovia-Lights with a large Bottom to put Water in, to prevent danger from the Sparks of the Candle flying upon the Powder-duſt, that may get into the Lanthorn, Dark-Lanthorns, Powder-Meaſures, Sope, Powder-Horns, Priming-Irons, Nippers, Plyers, Moulds to caſt leaden Bullets.

And for Inſtruments ſuch as follow, which every Gunner of a Ship ought to be furniſhed withal.

Callaper

Callaper Compaſſes large and ſmall, for taking the Diameters of the Baſe Ring, Body or Muzzle of a Gun, and the Diameters of Shot.

A New Rule called the Sea-Gunners Rule, whoſe uſe is ſhewed at the End of this Book.

Braſs Heights for Shot.
A Gunners Scale and Quadrant.
Braſs Compaſſes with Steel-points,

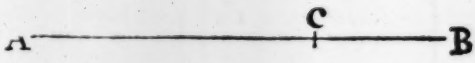
Which Inſtruments, and any other belonging to the Art of Navigation you may be furniſhed with, by *John Seller*, at the *Hermitage* in *Wapping*; with all ſorts of Books, and Maritime Charts, and Atlaſſes, for any of the known Parts of the World.

CHAP. XI.

Shewing an Eaſie way to diſpart a Piece of Ordnance.

FIrſt take the Diameter of the Piece upon the thickeſt Part, at the Breech of the Gun, with a Pair of Callaber Compaſſes, and ſee upon the Quadrant of your Callabers, how many Inches that is; the half of which Diameter take between a Pair of Compaſſes, and put that diſtance off upon a Sheet of Cartridge-Paper, which will make two Points upon the Paper, as A and B; then take the Diameter of the thickeſt part with your Callabers, and ſee how many Inches that Diameter is, And take the half thereof between your Compaſſes, and ſet one Foot in A, and the other Point in C upon the ſaid Line AB, at C.

Then



Then take the Diſtance from C, to B, on the Line, and that is the true Diſpart of the Piece; and if you take a Stick or Straw of that length, and ſet on the Muzzle faſtned with Wax, it will be a true Diſpart for that Piece.

CHAP. XII.

To Level a Piece of Ordnance to ſhoot Point-Blank.

TO ſhoot Point-Blank is to be underſtood, that when the Cylender of the Piece lyeth level with the Horizon, ſo that the Ruler of the Gunners Quadrant being put into the Mouth of the Piece, the Line and Plummet hangeth Perpendicular, then that Piece lyeth in its true Poſition, to ſhoot Point Blank.

And to make a good ſhot at a Mark, within Point-blank reach of the Piece, The Piece lying in that Poſition, as is before ſhewn; then ſet up your Diſpart upon the Muzzle; then if you put your Eye down to the higheſt part of the baſe Ring (as you took the Diameter of) and bring the top of the Diſpart in a righe-line, with the Ob-

Object at a Diſtance, that ought to be of the ſame Heighth from the Horizon at your Breech of the Gun and the Diſpart, then is your Sight or viſual Line alſo parallel to the Horizon, and if there be nothing defective in the Piece or Carriage, you will make a good Shot.

But if you intend to elevate your Piece, diſcharge it of ſome of the Quoins at the Breech, and by your Quadrant applyed to the Muzzle, you may elevate the Piece to what Angle you pleaſe; as may be performed by the New Sea Gunners Rule, whoſe Uſe is ſhewn at the latter End of this Book.

CHAP. XIII.

How to ſearch a Piece of Ordnance, to diſcover whether there be any Flaws, Cracks or Hony-combs in the Piece.

IN a clear Sun-ſhiny-day, take a Piece of Looking-glaſs, and reflect the Beams of the Sun into the Cavity of the Piece, by the means of which a clear Light will appear within the Piece, by which you may diſcover any Flaw or Honey-Comb therein.

Another Way.

Take a long Stick with a ſlit at the End of it, and put an End of Candle lighted, and put it into the Cylender, turning the Stick

Stick every way; and you may very well discover Flaws or Honey-Combs, if there be any in the Piece.

Another Way to discover Cracks.

Immediatly after you have discharg'd your Piece, let one be ready with a Tomkin to clap into the Mouth of the Piece, with a Piece of Sheep-skin wrapped about the Muzzle of the Piece, and the same time let one stop the Touch-hole; and if there be any Crack through the Metal a visible Smoak will appear.

Another Way.

If you strike a Piece of Ordnance with a smart stroke, with a Hammer on the Outside, and if you hear a hoarse sound, it is an evident Sign the Piece is not sound, but there is some Crack in it.

But if after every stroak with the Hammer you hear a clear sound, you may certainly conclude the Piece to be sound.

CHAP.

CHAP. XIV.

How Moulds, Formers and Cartridges are to be made for any ſort of Ordnance.

CArtridges are uſually made of Canvaſs, or Royal Paper; to make them firſt take the heighth of the Bore of the Piece, and allow $\frac{1}{7}$ part of the Diameter for the Vent, and make the breadth of the Cartridges three Diameters of the Chamber of the Piece, beſides the ſewing or paſting, and from the Cannon to the whole Culvering is allowed about two Diameters for the length, from the Culvering to the Minion, the Cartridge is two Diameters and a half, and from the Minion to the Baſe three Diameters.

To

To every ſort of Ordnance you muſt have a Former turn'd to the heighth of the Cartridge, which is $\frac{1}{7}$ parts of the Diameter of the Bore, and half an Inch longer than the Cartridge.

Before you paſte the Paper on the Former, tallow it, that the Canvaſs or Paper may ſlip off, without ſtarting or tearing.

If you make your Cartridges for Taper-bored Guns, your Former muſt be Taper'd accordingly; if you make your Cartridges of Canvaſs, allow an Inch for the Seams, but if you make them of Paper, allow $\frac{1}{4}$ of an Inch (more than three Diameters) for the paſting.

When your Cartridges are upon the Former, having a Bottom ready fitted, you muſt paſte the Bottom cloſe and hard round about; then let them be well dried, and mark every one with black or red Lead, or Blacking, how high they ought to be filled; and if you have no Scales nor Weights, theſe Diameters of the Bullets make a reaſonable Charge for a Cannon, 2 and $\frac{1}{2}$ for a Cannon, three Diameters for a Culvering, and 3 $\frac{1}{2}$ for the Saker; And for the leſſer Pieces 3 and $\frac{1}{2}$ of the Diameter of the Ball, and let ſome want of their weight againſt the time the Piece may be over-hot, or elſe you may endanger your ſelf and others:

thers: Note that at Sea the Guns are never charged with a Ladle, but with Cartridges.

CHAP. XV.

How much Rope will make Britchings and Tackles for any Piece.

IN Ships that carry Guns, the moſt experienced Gunners take this Rule; look how many Foot your Piece is in length, four times ſo much is the length of your Tackle, and your Britchings twice the length; and if the Ropes are ſuſpected of ſtrength, then you may nail down Quoins to the four Trucks of heavy Guns, that they may have no play; and if Breechings and Tackles ſhould give way in foul Weather, it is beſt immediacely to diſmount your Gun; that is the ſureſt way.

SECT.

What Powder is allowed for Proof, and what for Action.

FOR the biggeſt ſort of Pieces, as Cannon, take for Proof ⅘ of the weight of the Iron-ſhot, or for ſervice ⅔ the weight, for the Culvering almoſt the weight of the Shot for Proof and for Action; for the Saker and Falcon, take for Proof the weight of the Shot, and for Action ¾, and for leſſer Pieces the whole Weight of the Shot for ſervice; and for Proof give them one, and ½ of the Weight of the Ball in Powder.

CHAP.

CHAP. XVI.

How to know what Diameter every Shot muſt be of, to fit any Piece of Ordnance.

DIvide the Bore of the Piece into twenty equal Parts, and one of theſe Parts is ſufficient vent for any Piece, the reſt of the nineteen Parts muſt be the heighth of the Shot: But moſt Gunners now-a-days allow the Shot to be juſt one quarter of an Inch lower than the Bore of the Piece, which rule makes the Shot too big for a Cannon, and too little for a Faulcon; but if the Mouth of the Piece be grown rounder than the reſt of the Cylender within by often ſhooting; to chooſe a Shot for ſuch a Piece, you muſt try

try with ſeveral Rammer-heads, until you find the Diameter of the Bore in that Place where the Shot uſeth to lye in the Piece, and a Shot of one twentieth part lower than that Place, is ſufficient.

Every Gunner ought to try his Piece, whether it be not wider in the Mouth than the reſt of the Chaſe, and then proceed to chuſe his Shot.

To tertiate a Piece of Ordnance.

This word Tertiate is a Term principally uſed by foreign Gunners, meaning thereby only the meaſuring and examining the Fortification of Metals in a Piece, *tertiating*; becauſe it is chiefly to be meaſured and examined in three principal Parts of a Piece, *Viz.* at the Breech, the Trunions and the Mouth: And there are three Differences in Fortification of each ſort of Ordnance, either Cannon or Calverings, for they are either double fortified, ordinary fortified or leſſened, as Legitimate, Baſtard, or extraordinary Pieces: For the Cannon double fortified or re-inforced, hath fully one Diameter of the Bore in Thickneſs of Metal at her Touch-hole, and $1\frac{1}{2}$ at the Trunions, and $\frac{1}{2}$ at her Muzzle; and the ordinary Cannons

nons have $\frac{7}{10}$, at the Chamber $\frac{8}{10}$, at the Trunions $\frac{3}{4}$; The leſſened Cannons have $\frac{2}{3}$ at the Chamber, and $\frac{2}{3}$ at the Trunions, at the Muzzle $\frac{1}{2}$, *&c.*

Now that every Gunner may be aſſured of the Fortitude of any Piece of Ordnance, and ſo may the more ſafely and boldly allow her a due Loading and Proportion of Powder, both for Proof and Service, that ſhe may without danger perform her utmoſt Execution, you may obſerve this following Direction:

As for Example.

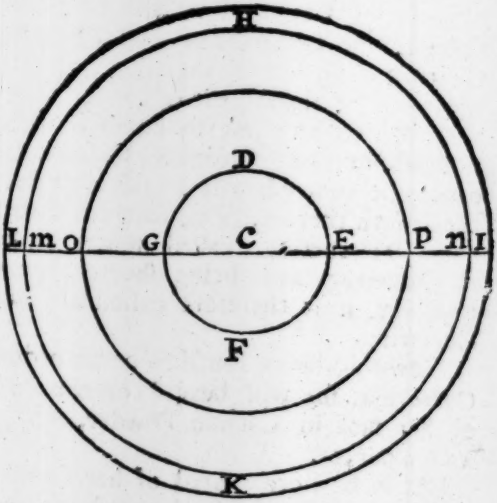
Suppoſe there is a Culvering that ſhooteth an Iron-ſhot of 17 *l.* with 13 *l.* of Corn-Powder, which is $\frac{4}{5}$ of the Weight of the Shot; the Queſtion is, whether ſhe may be able to bear ſo much Powder, and if need were, more which queſtion cannot be well anſwered without examining or tertiating her Metal, which may be thus performed.

Firſt with a Ruler draw a Line upon a Paper or Slate, as you may ſee in the annexed Figure, as the Line AB.

Then with a Pair of Compaſſes with reverſed Points, take the Circumference of the Bore of the Piece, and Meaſure the ſame upon an Inch-Rule.

Then

Then take the ſame Meaſure from any other Scale of equal parts of a competent ſize, and divide that diſtance into two equal parts with your Compaſſes, and having that diſtance in your Compaſſes, ſet one foot in the Point C, and deſcribe the circle D E F G, which circle is equal to the bore of the Piece.



Then with a pair of Calaber Compaſſes, take the Thickneſs or Diameter of the

Metal at the Touch-hole, and Meaſure the ſame upon a rule as before, and take that diſtance between your Compaſſes, and with half that diſtance ſetting one Foot in the point E deſcribe the circle H I K L, which ſhall repreſent the circumference of the Metal at the Touch-hole, ſo that you may take the Compaſſes and Meaſure the Diameter of the bore G E, which is equal to the diſtance of L G or E I which ſhews, that there is one Diameter of Metal round the Concave Cylinder of the Piece; you may therefore be ſure that it is an ordinary fortified Culvering; but to know if it be a Baſtard, or extraordinary Culvering, it cannot be known by the fortification but by the length thereof, being longer than ordinary, it is therefore called an extraordinary Culvering, and being ſhorter than the ordinary, it is therefore called a Baſtard Culvering.

Now this being found to be an ordinary Culvering, ſhe will bear $\frac{1}{4}$ of the weight of her ſhot in Cannon Powder, which is 13 *l.* 9 ounces.

But to be more aſſured of her fortitude, the meaſure of her Metal may be taken at her Trunions and Neck as followeth.

At the corniſhing before her Trunions, with a pair of Calaber Compaſſes, you may

may take the Diameter of the body of her Metal there, as you did before at the Touch-hole, and measure the same Diameter upon a rule, then take your Compasses and from the same scale as you did use before, take that distance and divide it in two equal parts, and setting one Foot of the Compasses in C describe the circle M N, and if found $\frac{7}{8}$ of the bore, it is the proportional fortification for an ordinary Culvering, and the like may be done with the Neck which the circle O P doth represent, and the distance from G to O being $\frac{7}{8}$ of the height of her bore, and is the due thickness of her Metal, for an ordinary Culvering at her Neck.

But if in taking the measures aforesaid there had been found at the Touch-hole from G to L (the thickness of one Diameter at the bore, and $\frac{1}{8}$ more, it would have signified that it had been a double fortified or a reinforced Piece, having also at the Trunions G M $\frac{1}{8}$, and at the Neck G O $\frac{1}{8}$ of the height of her bore, then she shooting an Iron shot of 17 *l.* would have endur'd 17 *l.* of Cannon Corn Powder to be loaded with, and to be fired without danger, and would conveyed the shot further than the ordinary could have done upon the like degrees of Mounture.

Contrariwiſe, if the Circles there had been found that from G to L had been but $\frac{7}{8}$ of the height of her bore at the Touch-hole, and at her Trunions but $\frac{3}{4}$ which is G M, and at the Neck from G to O but $\frac{7}{10}$ of the height of the bore, then ſhe would appear to be one of the leſſened or ſlender fortified Culverings, and muſt be allowed but 12 pound 9 ounces of Cannon Corn Powder, to convey her ſhot of 17 *l.* which upon like elevation will not carry a ſhot as far as the ordinary.

In this manner all other Guns are to be meaſured and tertiated only with this allowance withal that the Demy Culvering hath $\frac{1}{24}$ and the Saker $\frac{1}{12}$ and the Falcon $\frac{1}{6}$ more Metal comparatively than the whole Culvering hath.

And if a Piece is found that it is not truly bor'd, you muſt always reckon that the Piece is no otherwiſe fortified than ſhe is found to be, where her Metal is found to be thineſt.

How

How to make a Shot out of one Ship unto another in any Weather whatsoever.

IN time of ſervice when you are on a ſuddain to make a Shot at a Ship, and know not what diſpart will ſerve the Piece, then you muſt take your aim at what part of the Ship you judge to do moſt execution, and look along by the ſide of the Piece, as near as you may at the middle of the Breech unto the middle of the Mouth of the Piece, and ſo place her to the beſt advantage, and quoin up the tayl of the Piece faſt (for that giveth the true height of the mark) Then minding the ſteeridge take your beſt opportunity and give fire, and if the Sea be any thing grown, chooſe your Piece that is neareſt the Main-Maſt and in the lower Teer, if the Ship can keep her Ports open, for there ſhe doth leaſt labour; and when you are to make a Shot at a Ship, you muſt be ſure to have a good Helms-Man that can ſteer ſteady.

And he that giveth level muſt lay his Piece directly with that part of the Ship that he doth mean to ſhoot at. And if the

Enemy be to Leeward of you, then give fire when the Ship doth begin to aſcend or riſe upon a Sea, which is the beſt opportunity that doth preſent.

But if the Enemy is on the weather-gage of you, then wait an opportunity when the Ships do right themſelves; for if you ſhould give fire at the heelding of your Ship, then you would ſhoot over the other Ship; and if the Sea be high, there is no better time to give fire than when your Enemies Ship begins to riſe on the top of a Sea, for then you have a better mark than when ſhe is in the trough of the Sea: All which ſeveral obſervations muſt be managed, with a good judgment and diſcretion of the Gunner.

And he that is at the Helm muſt be Yare-Handed with the Helm, to obſerve the motion of the Enemy, to luff when the Enemy luffs, and to bear up when the Enemy bears up; and it is always good to level the Piece rather under the place you ſhoot at than over.

And if in a fight, if you intend to lay your Enemy, aboard then call up your Company either to enter or defend.

And if you are reſolved to enter, then be ſure to level your Baſes or other ſmall Guns ready to diſcharge to the beſt advantage you can at the firſt boarding, at ſuch a place

place where his Men have moſt recourſe; and if you can poſſibly, at boarding endeavour to take off his Rudder by a great ſhot, or at his Main Maſt &c.

In what Order to place your great great Guns in Ships.

IT is firſt to be conſidered that the carriage be made in ſuch ſort that the Piece may lie right in the middle of the Port, and that the Trucks or Wheels are not too high, for if they are too high, then it will keep the carriage, that it will not go cloſe to the Ships ſide, ſo that by that means the Gun will not go far enough out of the Port, except the Piece be of a great length; and alſo if the Ships heelds that way, the Trucks will always run cloſe to the Ships ſide, ſo that if you have occaſion to make a ſhot, you ſhall not bring the Trucks off the Ships ſide, but that will run too again; and the Wheel or Trucks being too high, it is not a ſmall thing will ſtay it, but will run over it.

And another inconveniency is, if the Trucks are too high, it will cauſe the Piece to have a greater reverſe or recoyl, therefore

for theſe reaſons it is good to have low Wheels or Trucks to a Gun aboard of a Ship.

The beſt poſition that the Gun can be in is, to place it in the very midſt of the Port, that is to ſay, that the Piece lying level at point blank, and the Ship to be upright without any heelding, that it be as many Inches from the lower ſide of that Port beneath, as it is upon the upper part above; and the deeper or higher the Ports are up and down, it is the better for making of a ſhot, for the heelding of a Ship, whether it be on the Lee or Weather ſide; for if you have occaſion to ſhoot forward or backward, the ſteeridge of the Ship will ſerve the turn.

It is alſo very bad to have the Orlope or Deck too low under the Port, for then the Carriage muſt be made very high, which is very inconvenient in ſeveral reſpects, for in firing the Piece it is apt to overthrow, as alſo in the working and labouring of the Ship in foul weather.

And alſo you have conſideration in placing your Ordinance in a Ship, for the ſhorteſt Ordinance is beſt to be placed out of the Ships ſide, for ſeveral reaſons.

1. For the eaſe of the Ship, for the ſhorter they are the lighter, and if the Ship

Ship ſhould heel with the bearing of a Sail, then you muſt ſhut the Ports, eſpecially thoſe Guns on the lower deck; then the ſhorter the Piece is, the eaſier it is to be taken in both for the ſhortneſs and weight alſo.

2. In like manner, the ſhorter the Piece lyeth out of the Ships ſide, the leſs it ſhall annoy them in the tackling of the Ships Sails, for if the Piece lyeth far out the Sheets, Tacks or Bowlines, it will be apt to be foul of the Guns.

For your long Guns they are beſt to be placed in the Gun-Room or any place, after on for a Stern-Chaſe, for two Reaſons.

1. The Piece had need to be long, or elſe it will not go far enough out that it may be no annoyance to the works of the Stern that may over-hang, and ſo may blow away the Counter of the Ships Stern.

2. The Pieces that are placed abaft, are required to be long, becauſe of the raking of the Ships Stern from below, ſo that the Carriages cannot come ſo near the Ports as they do by the Ships ſide, which is more up and down.

Alſo for ſuch like Reaſons as theſe, it is as well required to have long Pieces to be placed forward or in the Fore-Caſtle, &c.

And

And here note that there must be regard had to the making of the Carriages, both for Forward-on or After-on for the places of the foremost trucks, in taking notice if the Ships side do tumble in or out, and also the cumbering of the Deck or Orlope; in all these cases it must be left to a good judgment and experience, in the convenient placing of Guns in a Ship.

How much Rope will make Breechings and Tackles for Guns.

For the Tackles.

YOU may observe this Rule, that as many Feet as your Piece is in length, so many Fathom must your Rope be.

For the Breechings.

They must always be four times the length of the Piece with some overplus for fastning at both ends. If in foul weather your Breechings and Tackles should give way, you have no better way for the present to

to prevent danger, than immediately to dismount the Piece.

It is also approved by able Gunners, that the Rammers and Spunges made with small Hawser should be armed close and hard with strong and twisted Yarn, from the Rammers end quite to the Spunge, which would much stiffen and make it more useful and lasting to ram both Wad and Bullet close to the Powder.

Let the head of the Rammers be of good Wood, and the heighth one Diameter, and ½ thereof in length, or very little less then the heighth of the shot next the Staff; it must be turned small that a ferril of Brass may be put thereon, to save the head from cleaving; when you ram home the shot, the heads must be bored ½, for the Staff to be put in and fastned with a Pin through, and the Staff-length a foot more then the concave of the Gun.

CHAP.

CHAP. XVII.

Of Powder.

Several things neceſſary to be known by a Gunner; but eſpecially of Powder.

THE efficient cauſe for expelling the Shot is the Fire that is made of Powder, that is compounded of Salt-Petre, Brimſtone and Charcoal.

The Salt-Petre gives the Blow or Report.

The Sulphur takes Fire, and the Coal rarifies the other two, to make them Fire the better.

Two ſorts of Gun-Powder are commonly in uſe.

One is made of five Parts of Salt-Petre, one of Brimſtone, and one part of Charcoal.

The

The other (being ſtronger) is made of ſix one and one.

That of five one and one is generally uſed for great Guns, the other for Muskets and ſmall Arms.

And it hath been generally obſerved, that forty two pound of Powder of five one and one, is ſtronger than forty five pound of four one and one; and forty pound of ſix one and one works greater effect, than forty two pound of five one and one, although all contain thirty pound of Salt-Petre.

Anciently they made Powder of four one and one; but this Powder by experience being found too weak, is not now in uſe.

That Powder which at this day is received into their Majeſties Magazine at the Tower of *London*, is made of ſix one and one.

To know good Powder.

1. The harder the Corns are in feeling, by ſo much the better it is.

2. When the Powder is of a fair Azure or French Ruſſet colour, is it judged to be a very good ſort and to have all its Ingredients well wrought, and the Petre to be well refined.

3. Lay

3. Lay five or ſix Corns upon a white piece of Paper three fingers diſtance one from another, then fire one, and if the Powder is good they will all fire at once and leave nothing but a white chalky colour on the Paper; neither will the Paper be toucht: But if there remains a groſſneſs of Brimſtone and Petre, it diſcovers the Powder to be bad.

And take this for a general Rule, for a ſign of good Powder; that which gives fire ſooneſt, ſmoaks leaſt, and leaves leaſt ſign behind it, is the beſt ſort of Gun-Powder.

To preſerve Powder from decaying.

To preſerve good Powder, Gunners ought to have that reaſon to keep their Store in as dry a place that can be had in the Ship, and every Fortnight or three Weeks to turn all the Barrels and Cartridges upſide down, ſo that the Petre may be diſperſed to every part alike; for if it ſtands long, the Petre will always deſcend downwards, and if it be not well ſhak'd and moved, it will want of its ſtrength at the top, and 1 *l.* at bottom with long ſtanding will be ſtronger then 3 at the top.

To

To find the Experimental Weight of Powder (Tower-Proof) that is found convenient for Service, to be used in Guns of several Fortifications (or thickness) and by consequence Strength of Metal.

TO find the strength of Guns the brief Rule is thus, First find the Diameter of the bore (or Chamber of the Gun) where the shot lies, then the true fortified Iron Guns ought to be 11 of those Diameters in the circumference of the Gun at the Touch-hole, 9 at the Trunions, and 7 at the Neck, a little behind the Mouth or Muzzle-ring where the dispart is set.

But Brass Guns having the same weight of Powder are as strong at nine Diameters of the Chamber bore about the Gun at the Touch-hole, and seven Diameters at the Trunions, and five at the Neck.

This

This is the Rule of true bored and true fortified Guns; and for those more or less fortified, observe the Proportions in this following Table.

	Brass		*Iron*
More Fortified	11 to 12	*Diameters*	13 to 14
True Fortified	9	*Diameters*	11
Less Fortified	8 to 7	*Diameters*	10 to 9

Weight of Powder for Service is proportioned by the Numbers of Diameters of the Bore about the Gun at the Touch-hole, for such Guns so qualified as in the foregoing Table, *viz.* and to load them accordingly.

To know whether the Trunions of any Gun are placed right.

Measure the length of the Cylender from the Muzzle to the Britch, and divide the Length by 7, and divide the Quotient by 3, and the Product will shew how many the Trunions must stand from the bottom of the bore of the Piece, and that they ought to be placed so that $\frac{1}{3}$ of the Piece may be seen above the Center of the Trunions.

The

The Practical way of making Gun-Powder.

The Essential Ingredients for making Gun-Powder are three, *viz.* Salt-Petre, Brimstone and Charcoal, and of these there are to be three several quantities and proportions, according to the use intended for; and for the best Powder that is now made, there is commonly used these proportions.

Salt-Petre,——4, 5, 6 *Parts.*
Brimstone,——1 *Part.*
Charcoal,——1 *Part.*

The Cannon Powder hath commonly of Salt-Petre four times so much as of Brimstone and Charcoal, and for Musket Powder it is usually made five times as much Salt-Petre as of Brimstone and Coal.

Now having the Proportional quantity of each of these Ingredients, put all the Salt-Petre together into a Caldron, and boyl it with so much Water as will serve to dissolve it with; being so dissolved, it ought to be washed and lay'd upon a clean place; this done, beat the quantity of Coal into dust, then put this Charcoal dust being finely beaten

ten into the diſolved Petre, and incorporate them very well together, and as you mingle them, put in by little and little the Sulpher very well beaten; when this mixture of Salt-Petre Brimſtone and Coal are well incorporated, lay it forth to dry a little; when the ſame mixture is ſomewhat dryed and is very well mixed, ſift it well through a Sieve; then caſting Water or Vinegar upon it, corn it, and when you have ſo done, dry it againſt the Fire and the Gun-Powder is made: There are divers ways to grind Gun-Powder; the beſt way is to ſtamp it in Mortars with a Horſe-mill or Water-mill, for the Powder is thereby moſt finely beaten and with leaſt labour; and to know if it be well done, you may with a Knife cut in pieces ſome of this Compoſition, and if it appear all black it is well done, but if any of the Brimſtone or Petre is ſeen, it is not incorporated enough.

The manner to ſift Powder is thus,

Prepare a Sieve with a bottom of thick Vellom or Parchment, made full of round holes, then moyſten the Powder which ſhall be corned with Water, put a little Bowl into the Sieve, then ſift the Powder ſo as the Bowl rowling up and down in the Sieve may break the clods of Powder, and make it by running through the little holes to corn.

To

To Renew and make good again any ſort of Gun-Powder, having loſt its Strength by moiſture, long lying, or by any other means.

Having moiſtned the ſaid Gun-Powder with Vinegar or fair Water, beat it well in a Mortar, then ſift it through a Sieve or fine Searce; for every *l.* of Gun-Powder mingle one Ounce of Salt-Petre that hath been pulveriſed, and when you have ſo done beat and moiſten this mixture again, until by ſo breaking or cutting with a Knife, there is no ſign of Salt-Petre or Brimſtone in it: Alſo corn this Powder when it is incorporated with the Petre, as it ought to be, and you have done.

CHAP.

CHAP. XVIII.

How to make Hand-Granadoes to be Hove by Hand.

THere is good uſe made of Hand-Granadoes in Aſſaults and Boarding of Ships; theſe are made upon a Mould made with Twine, and covered over with Cartridge Paper and Musket Bullets cut in two, put with Paſt and bits of Paper thick on the out-ſide. After you have doubled the Shells, paſt on ſome at a time, and let it dry, and put ſome more until it be quite full; then dip it in ſcalding Roſſen or Pitch and hang it up and it is for your uſe: But you muſt have the innermoſt end of the Twine left out, and before you pitch it you muſt draw out the Twine and ſtop the hole, and then pitch it.

To

To load them, fill these Shells with Gun-Powder, then make a Fuze of one pound of Gun-Powder and six Ounces of Salt-Petre and one of Charcoal, and fill the Fuze; then knock it up to the head within one quarter of an inch, which is only to find it by night.

Stop the rest of the holes well with soft Wax; your first Shells must be coated with Pitch and Hurds lest it should break with the fall; and be sure when you have fired the Fuze, suddenly cast it out of your hand, and it will do good execution.

CHAP. XIX.

How to make Fire-Pots of Clay.

Fire-Pots and Balls to throw out of Mens hands may be made of Potters-Clay with Ears to hang lighted Matches to them; if they light on a hard thing they break and the Matches fire the Powder, and the half Musket Bullets contrived on them, as in the last Chapter, disperse and do much mischief.

Their mixture is of Powder, Petre, Sul-

pher, Sal Armoniack of each one pound, and four Ounces of Camphire pounded and ſearced and mixt well together, with hot Pitch, Linſeed Oyl or Oyl of Petre; prove it firſt by burning a ſmall quantity, and if it be too ſlow add more Powder, or if it be too quick then put more Oyl or Roſin, and then it is for your uſe.

SECT. I.

How to make Powder-Cheſts.

You muſt nail two Boards together like the ridge of a Houſe, and prepare one Board longer and broader for the bottom: Between theſe three Boards put a Cartridge of Powder, then make it up like a Sea-Cheſt and fill it with pibble Stones, Nails, Stubbs of old Iron; then nail on the Cover and the ends to the Deck, in ſuch a place as you may fire the Powder underneath through a hole made to put a Piſtol in: Theſe are very uſeful to annoy an Enemy if they board you.

To make Stink-Balls.

Take Gun-Powder 10 *l.* of black Pitch 6 *l.* of Tarr 10 *l.* Salt-Petre 8 *l.* Sulpher Ca-

Calafornia 4 *l.* melt theſe over a ſoft Fire together, and being well melted put 2 *l.* of Cole duſt of the Filings of Horſes Hoofs 6 *l.* Aſſa Fætida 3 *l.* Sagapenum 1 *l.* Spatula Fætida half a *l.* Incorporate them well together and put into this matter ſo prepared old Linnen or Woollen Cloath, or Hemp or Tow as much as will drink up all this matter, and of theſe make them up in Balls of what bigneſs you pleaſe, and being thrown between Decks will be a great annoyance to the Enemy.

CHAP. XX.

The Properties Office, and Duty of a Sea-Gunner.

1. A Gunner ought to be a ſober, wakeful, luſty, patient, prudent and quick Spirited Man; he ought alſo to have a good eye-ſight and a good judgment in the time of ſervice, ſo to plant his Piece to do moſt hurt on execution, either to the Hull or rigging of a Ship, as may be moſt expedient according to the appoinment of the Commander.

2. A Gunner ought to be skilful in Arithmetick and Geometry, in the making of all kind of Artificial Fire-Works, especially for service.

3. A Gunner ought to procure with all his power the Friendship and Love of every Person, and to take great care of his charge for his own safety as well as the Ship and all the Mens lives, by having special regard unto his Powder Room and to be well satisfied in the carefulness of those that he doth intrust to manage the business there, and to see that the Yeoman is careful always to keep a good and large Lanthorn, and to be kept whole, that it may prevent the flying in of the dust of the Powder, for the neglect of which it hath sometimes been conjectured that some Ships have been blown up and lost for want of care in the Powder Room.

4. A Gunner ought at the receipt of his charge, to make an Inventory of all such things as shall be committed to him, as well to render an account as to consider the want of such Materials as are necessary to the well performance of his duty.

5. A Gunner ought to have his Gun-Room always ready furnished with all necessaries belonging to his Art, which ought always to be in readiness, *viz.* Ladles, Rammers,

mers, Spunges, Gun-Powder, Balls, Tamkins, Wadds, Chain-ſhot, Croſs-bar-ſhot, Quoins, Crows, Tackles, Breechings, Powder-Horns, Canvaſs, and Paper for Cartridges, Forms for Ladles, Cartridges, Needles and Threed to ſow and bind the Cartridges, Candles, Lanthorns, Handſpikes, Poleaxes, little Hand-Baskets, Glew and Paſt, with a ſufficient Crew of able and expert Seamen, being yare-handed to travers a Piece, to Charge, Diſcharge, Mount, Wadd, Ram, make Clean, Spunge, and Prime and Scoure, and readily to do and perform any thing belonging to the Practical Part of Gunnery.

6. A Gunner ought always to have a Ruler about him, and a pair of Compaſſes, and Callabers to meaſure the heighth and length of every part of his concavity, and the length depth and wideneſs of every Ladle whereby he may know whether his Piece is laden with too much Powder, or is charged with a leſs quantity than it ought to have.

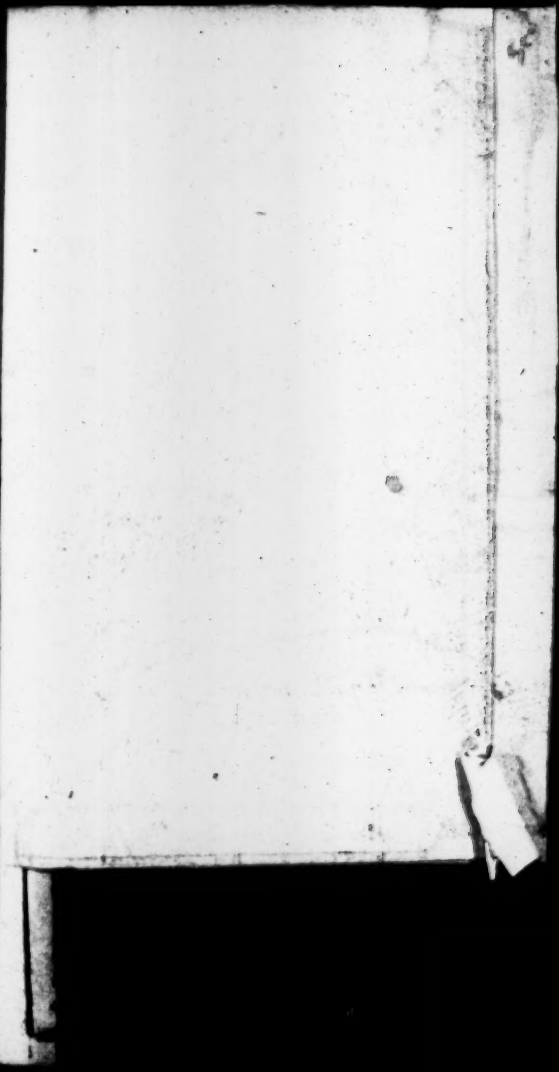
7. A Gunner ought to know the length and weight of all manner of Pieces, and be able to give an account readily how much Powder is a due charge for every Piece, and how many times a Piece may be ſhot off without harm, and how each kind of Piece ſhould be charged with the Powder, Tamkin, Ball and Wadd.

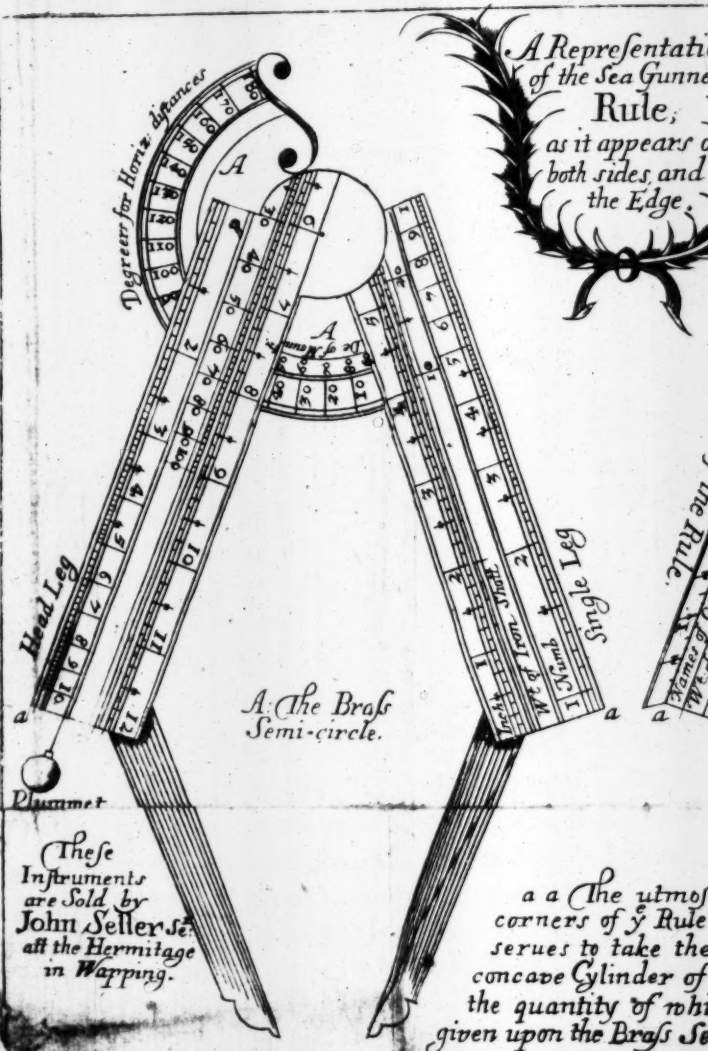
8. A

8. A Gunner also must be skilful to make Salt-Petre, to refine and sublime Salt-Petre, to make divers sorts of Gun-Powder to purifie Brimstone, to amend any sort of Powder when it hath lost its vertue and force, and to know how much Salt-Petre ought to be put to the said unserviceable Powder, and to make it strong as it was before, and how many times the Salt-Petre that is put into the Powder ought to be refined.

9. A Gunner that serves at Sea must be careful to see that all their great Ordance be fast breeched, and that all the furniture be handsome and in a readiness as was said before, and that they are circumspect about their Powder in the time of service, and to have an especial care of the Linstocks and Candles for fear of their Powder and their Fire-works, and the Oacum, which is very dangerous, and to keep your Pieces (as neer as you can within): And also that you keep their Touch-holes clean without any kind of dross falling in them; and it is good for the Gunner to view his Pieces and to know their perfect dispart, and to mark it upon the Piece or else in a Book or Table, and name every Piece what it is and where she doth lie in the Ship, and note how many inches halfs and quarters of inches the dispart cometh unto.

AN




A Representati
of the Sea Gunne
Rule,
as it appears
both sides and
the Edge.
Degrees for Horiz. distances
A
Head Leg
Single Leg
Plummet
a
a
A: The Brass
Semi-circle.
These
Instruments
are Sold by
John Seller Se.
att the Hermitage
in Wapping.
a a The utmos
corners of y Rule
serues to take the
concave Cylinder of
the quantity of whi
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esentation
ea Gunners
Rule,
ppears on
ides and
e Edge.

Inches on the edge of the Rule.

Names of Guns
Wt. of Bore
Wt. of Shot
Length of Shot
Bore of Ladle
Wt. of Powder

Brass tongues to turn into the rule and single Leg

These Rules may be made 12. or 18 Inches in length when open.

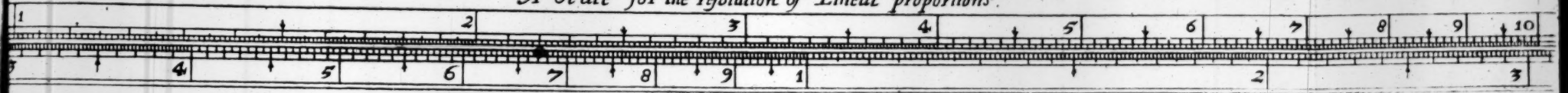
to perform the use of a Head Leg pair of Callabrus

Inches on the edge of the Rule.

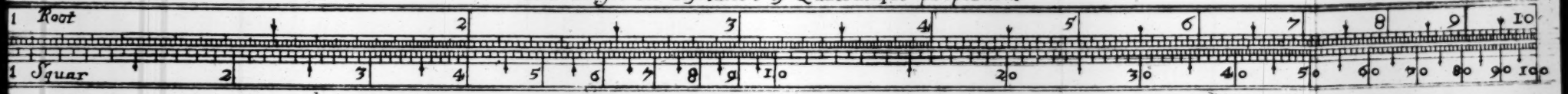
1 Root
1 Squar
1 Root
1 Cube

most
ule w:ch
the
of a Gun
hich is
Semicircle.

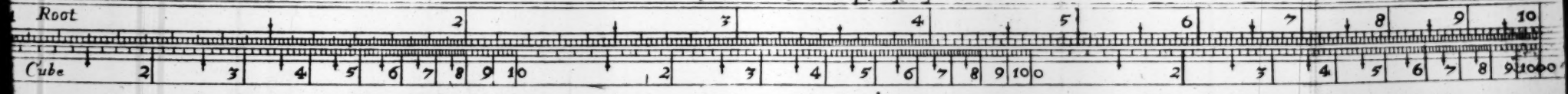
A Scale for the resolution of Lineal proportions.



A Scale for the resolution of Quadratique proportions



A Scale for the resolution of Cubique proportions



AN APPENDIX,

Shewing the Use of a

Proportional Scale

In several Questions in

ARITHMETICK,

In Lineal, Quadratick and Cubical Proportions, in the Mensuration of Superficies and Solids, and the Extraction of the Square and Cube-Root.

The Figure of which Scale is annexed to the Front of this Page.

As also the use of a New Rule, called the Sea-Gunners-Rule, containing an Epitome of the Art of Gunnery in it self.

By *John Seller.*

London, Printed in the Year, 1691.

CHAP. I.

A Deſcription of the Proportional Scale and its Uſe in the Art of Gunnery.

THere are three Lines upon the Scale,

One for { Lineal, Quadratick, Cubical, } Proportions.

The uppermoſt Line is for the Reſolutions of all Lineal Proportions, between Numbers Lines and Superficies, this Line being a ſingle Line of Numbers which is broken in the midſt and laid ſide by ſide, for the greater facility in their Operations.

The ſecond or middlemoſt is for the Reſolution of all Quadratick Proportions, between Lines and Superficies and the extraction

traction of the Square Root, several of which Questions may be answered by inspection only.

The third and lowest Line is for the Resolutions of all Cubical Proportions between Numbers, Lines and Solids, and the extraction of the Cubick Root.

Numeration on the Lines.

PROP. I.

A whole number consisting of two, three or four places, being given, to find the point on the Scale representing the same.

The upper Line (that is for Lineal Proportion) in two parts (*i. e.*) a line of Numbers broken and put side by side, the upper Line begins at 1, and if that be called one then the next figure must be called 2, and the next 3 and so to 10; but if you call the first 1, 10 then the next figure 2 you must call 20, the next 30, and so to 100.

And if you call the first 1, 100 then the next is 200, and the next 300, and so to the furthest 10, and that will be a thousand, and all the other intermediate Divisions are the tenth parts of Integers. The same way of Nume-

Numeration as is explained in this is to be underſtood of all the reſt of the Lines.

Example 1.

I would find the Number 25 on the Rule, I call the firſt 1, 10 and the ſecond figure 20, and tell 5 tenths more which are alſo Intigers, where you will find a long ſtroke and that is 25.

Note that every fifth of the grand intermediate Diviſions, are drawn forth with a longer Line than the reſt, for eaſe of counting.

Example 2.

Let it be required to find the place of 144 upon the upper Line, call the firſt 1 upon your Line 100 for your firſt figure 1, then for 40 tell 4 of the grand Diviſions for your ſecond figure, and for the third figure which is 4 count four of the ſmall intermediate Diviſions, that very point is the place upon the Line repreſenting 144.

Example 3.

Let it be required to find the place of 1690, for your firſt figure 1, count the 1 at the beginning to be 1000 for your ſecond figure

figure 6 count 6 of the grand Diviſions which is 600, and for 90 count 9 tenths more which is the very point repreſenting 1690.

Note by theſe examples you may perceive that the figures 1, 2, 3, 4, 5, 6, 7, 8, 9. do ſometimes ſignifie themſelves alone, ſometimes 10, 20, 30. *&c.* ſometimes 100, 200, 300, *&c.* as the works thereby doth require.

And by this varation and change of the Powers of theſe Numbers from 1 to 10 or 100 or 1000, any proportion either Arithmetically or Geometrically may be wrought; one, whereof I will inſert for your better exerciſing on the Scale, by the often practice whereof you will find the work facile and delightful, which ſhall be this following.

PROP. II.

Having two Numbers given, to find as many more as you pleaſe which ſhall be in continual proportion one to another as the two numbers were

For

For the working this Propoſition, this is the Rule.

Place one foot of the Compaſſes in the firſt given Number, on the upper line, and extend the other foot to the other given Number; then may you turn from that ſecond Number, to a third, to a fourth, (as far as you can go on the upper line) then to a fifth, ſixth, if the rule will admit.

Example.

Let the too given Numbers be 2 and 4, place one foot of your Compaſſes on 2, and extend the other foot to 4, that foot which now ſtandeth in 2, being turned over will reach to 8, and ſo far it will come upon the upper line; then bring it to 8 in the lower line, and turn the Compaſſes from 8 to 16, and from 16 in the upper line to 32, and from 32 to 64, and from 64 to 128, to 256 to 512 in the upper line, and ſo you may proceed until you come to 4096.

Again let the 2 Numbers be 10, and 12, which you will find in the lower line, and that Extent will reach from 12 to 1,4,4, and from thence to 17, 28.

But if the Numbers were 1 and 12, which you must find on the lower line, then the third proportional will be 144, and the fourth 1728, and all with the same extent of the Compasses.

CHAP. II.

Multiplication by the Proportional Scale.

IN Multiplication the Proportion is this: As 1 upon the line is to one of the Numbers to be Multiplied, so is the other Number to be Multiplied to the Product of them, which is the Number sought.

Example. 1.

Let it be required to Multiply 5 by 7, the Proportion is as 1 to 5, so is 7 to 35.

Therefore set one Foot of the Compasses in 1, in the lower line and extend the other Foot to 5, with that extent of the Compasses, place one Foot in 7, and the other Foot will fall on 35, which is the Product, (which is performed on the lower line) by extending from

from 1 in the middle of the Line to 5 backwards, the ſame extent the ſame way will reach from 7 to 35, the Product required.

Example. 2.

Let it be required to Multiply 34 by 9, the Proportion is, as 1 is to 9, ſo is 34 to 306, ſet one Foot of the Compaſſes (in the lower Line) from 1 or 10, in the middle, to 9 the ſame extent, will reach from 34 to 306.

Otherwiſe ſet one Foot in 1, and extend the other to 34, the ſame extent from 9 ſhall reach to 306.

Example. 3.

Let it be required to Multiply 8, $\frac{75}{100}$ by 6, $\frac{45}{100}$ the Proportion is as 1 to 8,75, ſo is 6,45, to 56,48, ſet one Foot (in the lower Line) from 1 to 8, 75, the ſame extent the ſame way will reach from 6,45, to 56,44, *fere.*

Or if you ſet one Foot in 1, and extend the other to 6, 45, the ſame extent ſhall reach from 8,75, to 56,44 almoſt, or 56$\frac{1}{4}$.

CHAP.

CHAP. III.

Diviſion by the Proportional Scale.

IN Diviſion there are 3 things to be taken notice of, *viz.*

The { *Dividend, or Number to be Divided.*
Diviſor, the Number by which the Dividend is to be divided.
Quotient, which is the Number ſought.

And as often as the Diviſor is contained in the Dividend ſo often doth the Quotient contain Unity.

For the working of Diviſion this is the Analogy or Proportion.

As the Diviſor, is to Unity or 1, ſo is the Dividend to the Quotient.

Example. 1.

Let it be required to divide 35 by 7, The Proportion is as 7 to 1, ſo 35 to 5; ſet one

one Foot of the Compaſſes in 7, (in the lower Line) and extend the other Foot to 1, that ſame extent will reach from 35 to 5, which is the Quotient: otherwiſe extend the Compaſſes from 7 to 35, that ſame extent will reach from 1 to 5.

Example. 2.

Let it be required to Divide 34 by 306, the Proportion is, as 34 is to 1, ſo is 306 to 9; extend the Compaſſes from 34 to 1, (in the lower Line) the ſame extent the ſame way, will reach from 306 to 9 which is the Quotient; or if you extend the Compaſſes from 34 to 306, the ſame extent ſhall reach from 1 to 9.

Example. 3.

Let it be required to divide 5644, by 8,75, the Proportion is as 8,75 is to 1, ſo is 56,44 to 6,45; extend the Compaſſes (in the lower Line) from 8,75 to 1, the ſmae extent the ſame way will reach from 56,44 to 6,45: or extend them from 8,75 to 56, 44, the ſame extent will reach from 1, to 6, 45, as before; now to know how many Figures are to be ſeparated for a Decimal Fraction in the Quotient; I refer you to the

Eighth Note of the Firſt Chapter of this Treatiſe.

CHAP. IV.

The Golden Rule Direct.

THis Rule may well be termed the *Golden Rule*; it being the moſt uſeful of any others: for having 3 Numbers given, you may by it find a fourth, in proportion to them, as by divers Examples following, ſhall be made plain: And this *Rule* is performed upon the *Scale*, with eaſe and Exactneſs; And for the working of it upon the Scale of proportion, this is the general Analogy.

As the firſt Number given, is to the ſecond Number given, ſo is the third Number given, to the fourth Number required: Or as the firſt Number given, is to the third Number given, ſo is the ſecond Number given, to the fourth Number Required.

Therefore, always extend the Compaſſes from the firſt Number to the ſecond, and that diſtance or extent applyed the ſame way upon the Line, ſhall reach from the third

third to the fourth Number required. Or otherwiſe extend the Compaſſes from the firſt Number to the third, and that extent applied the ſame way ſhall alſo reach from the ſecond to the fourth. Either of theſe ways will effect the ſame things; and it is neceſſary thus to vary the Proportion, ſometimes to avoid the opening of the Compaſſes too wide, for when the Compaſſes are opened to a very large extent, you can neither take off any Diſtance exactly, nor give ſo good an Eſtimate of any parts required, as you may do when they are opened to a leſſer diſtance: But this you will find out beſt by Practice and therefore I will now proceed to examples.

Example. 1.

If 45 Yards of Cloth coſt 30 *l.* what will 84 coſt at the ſame rate?

Analogies.

As 45, to 30, ſo 84, to 56. Extend the Compaſſes from 45 to 30, (on the lower Line) the ſame extent the ſame way will reach from 84 to 56 *l.* the Price of 84 Yards. Or extend the Compaſſes from 45 to 84, the ſame extent will reach from 30 to 56, as before.

Eighth Note of the First Chapter of this Treatise.

CHAP. IV.

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As the first Number given, is to the second Number given, so is the third Number given, to the fourth Number required: Or as the first Number given, is to the third Number given, so is the second Number given, to the fourth Number Required.

Therefore, always extend the Compasses from the first Number to the second, and that distance or extent applyed the same way upon the Line, shall reach from the third

third to the fourth Number required. Or otherwiſe extend the Compaſſes from the firſt Number to the third, and that extent applied the ſame way ſhall alſo reach from the ſecond to the fourth. Either of theſe ways will effect the ſame things; and it is neceſſary thus to vary the Proportion, ſometimes to avoid the opening of the Compaſſes too wide, for when the Compaſſes are opened to a very large extent, you can neither take off any Diſtance exactly, nor give ſo good an Eſtimate of any parts required, as you may do when they are opened to a leſſer diſtance: But this you will find out beſt by Practice and therefore I will now proceed to examples.

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If 45 Yards of Cloth coſt 30 *l.* what will 84 coſt at the ſame rate?

Analogies.

As 45, to 30, ſo 84, to 56. Extend the Compaſſes from 45 to 30, (on the lower Line) the ſame extent the ſame way will reach from 84 to 56 *l.* the Price of 84 Yards. Or extend the Compaſſes from 45 to 84, the ſame extent will reach from 30 to 56, as before.

Example. 2.

If 100 *l.* yeilds 6 *l.* Intereſt for one Year, or 12 Months, what ſhall 75 *l.* yeild ?

The Analogy.

As 100 is to 6, ſo is 75, to 4, 50. Extend the Compaſſes (upon the lower Line of the Scale of Lineal proportion) from 100 to 6, the ſame extent will reach from 75, to 4, 50, which is 4 *l.* 10 *s.* and ſo much will 75 *l.* yeild Intereſt in one Year.

Example. 3.

If 75 *l.* yeilds 4 *l.* 10 *s.* or 4 $\frac{1}{2}$ 150 Intereſt for one Year or 12 Months, what will 105 *l.* yeild? As 75 to 4,50, ſo is 150 *l.* to 9 *l.* Extend the Compaſes from 75 to 4, 50, the ſame extent will reach from 150, to 9 which is 9 Pounds, the Intereſt of 150 *l.* for one Year.

CHAP.

CHAP. V.

The Golden Rule Reverſe.

IN this Reverſe or backward Rule of Three, this Note is eſpecially to be Obſerved, That if the third Number be greater than the firſt, then the fourth Number will be leſs than the ſecond. And on the Contrary, if the third Number be leſs than the firſt, then the fourth Number will be greater than the ſecond; as by example.

Example 1.

If 12 Work-men do a piece of Work in in 8 days, how many Work-men ſhall do the ſame piece of work in 2 days?

Here it is to be noted that in the Queſtion, 12 is not the firſt Number, (though it be firſt named) but 2, for the Middlemoſt Term of the three, muſt be of the ſame kind with the fourth Number, that is to be ſought;

as

as in this example it is Men, therefore 12 which are Men, muſt ſtand in the middle or ſecond place, becauſe the fourth Number which is to be ſought is alſo Men, and therefore the Numbers will ſtand thus.

Days, Men, Days, Men.
2——12——8——48,

For if 8 days require 12 Men, then 2 days (which is but a fourth part of 8 days) ſhall require four times 12 Men, that is 48 Men; for here leſs requires more, that is, leſs time more Men; and hence the work is contrary to the Direct Rule: wherefore to effect it, extend the Compaſſes from 2 to 8, the ſame extent will reach from 12, (the contrary way on the lower Line) to 48, which is the Number of Men that will effect the ſame Piece of work in two days.

Example 2.

If 1 Cloſe will graze 21 Horſes for 6 weeks how many Horſes will the ſame cloſe graze for 7 weeks? Extend the Compaſſes from 6 to 7, for you muſt always extend your Compaſſes to Numbers of one kind, or Denomination, (as here 6 and 7 are both Horſes) the ſame extent from 21 backwards to 18,

and

and ſo many Horſes will the ſame Cloſe graze in 7 weeks,

CHAP. VI.

Of Duplicate Proportion performed by the Scale.

DUplicate Proportion is ſuch Proportion as is between Lines and Superficies, and between ſuperficies and Lines.

1. *Of the Proportion of Lines to Superficies,*

In this Caſe extend the Compaſſes, from the firſt to the ſecond Number of the ſame denomination, (taken upon the upper Line of the Scale of quadratique proportion) which ſhall give the diſtance (upon the lower Line of the ſame Scale) from the third Number unto the fourth.

Example. 1.

If the Diameter of a Circle be 14 Inches, and the Area, or ſuperficial Content thereof be 154 Square Inches, what will be the content

tent of another Circle, whoſe Diameter is 28 Inches; extend the Compaſſes from 14 to 28, (on the upper Line, of the Scale of Quadratique Proportion) that extent ſhall reach from 154 in the lower Line of the ſame Scale, to 616, and that is the Area or content of a Circle whoſe Diameter is 28.

II. *Of the Proportion of Superficies to Lines.*

In this caſe extend the Compaſſes unto half the diſtance, between the two Numbers of the ſame denomination; that ſame extent ſhall reach from the third Number to the fourth required.

Example. 1.

Let there be two Circles given, the Area or content of one being 154, and its Diameter 14, the Area of the other Circle is 616, what is the length of its Diameter upon the lower Line of the Scale of Quadratique Proportion? divide the diſtance between 154, and 616 into two equal parts, then with that diſtance ſet one foot in 14, and the other ſhall fall upon 28.

Ex-

Example. 2.

There is a piece of Land containing 20 Pole ſquare worth 30 *l.* there is another piece worth 91 *l.* 16 *s.* how many Pole ſquare ought that piece to contain? divide the ſpace between 30 *l.* and 91 *l.* 16 *s.* into two equal parts, then ſet that foot in 20 Pole, and the other Foot will reach to 35 Pole, and ſo many Pole ſquare muſt the Land be that is worth 91 *l.* 16 *s.* Note that 16 ſhillings upon the Line is ⅘.

CHAP. VII.

Of Cubical Proportion.

CUbical Proportion is ſuch a proportion as is between Lines and Solids, or betwen Solids and Lines.

1. *Of the Proportion between Lines and Solids.*

In this caſe extend the Compaſſes from the firſt Number to the ſecond, of the ſame denomination

nomination, that extent being placed (in the lower Line of the Scale of Cubical proportion) from the third Number to the fourth answereth the Question.

Example

There is a Bullet whose Diameter is 4 Inches, weighing 9 *l.* (what shall another Bullet of the same Metal weigh) whose Diameter is 8 Inches? Extend the Compasses from 4 to 8 (in the upper Line, the same extent will reach (in the lower Line, from 9 to 72, the weight of the Shot whose Diameter is 8 Inches.

2. *Of the Proportion of Solids to Lines.*

In this case extend the Compasses into the third part of the distance between the two Numbers of like denomination, the same extent shall reach from the third to the fourth Number.

Example.

The weight of a Cube being 72 Pound, the side thereof is 8 Inches, and the weight of another Cube of the same matter, weighing 9 *l.* what must the side be? Upon the lower Line, divide the distance between 9, and

and 72, into three equal Parts; then ſet one Foot of that diſtance in 8, and the other Foot ſhall reſt in 4, the length of the ſide of the Cube required.

CHAP. VII.

To Extract the Square Root, by the Proportional Scale, by Inſpection.

TO Extract the Square Root, is to find a mean Proportional Number, between 1 and the Number given, which is commonly done, by dividing the Square between them into two equal Parts; but upon the Scale of Quadratique proportion, it is found by Inſpection; therefore if you ſeek 36 (in the lower Line of Quadratique Proportions) you will find in the upper Line, right againſt it 6, which is the Square Root thereof; in the ſame manner you may find the Square-Root of 81 to be 9, and of 144 to be 12, and of 256 to be 16.

CHAP.

CHAP. IX.

To Extract the Cube Root upon the Proportional Scale, by Inſpection.

Example.

LEt it be required to find the Cube Root of 216; ſeek (in the lower Line of the Scale, of Cubical proportion) for 216, and in the upper Line, right againſt it you will find 6, the Cube Root required. In like manner you will find the Cube Root of 729, to be 9, of 1728, to be 12.

CHAP. X.

Of the Menſuration of Divers Reguler Superficial Figures by the Proportional Scale.

I. Of the Circle.

Example. 1.

THE length of the Diameter of any Circle given, to find the Circumference thereof. The Proportion between the Diameter and the Circumference of any Circle, is, as 7 to 22, wherefore if the Diameter of a Circle given, be 12 Inches, the Circumference thereof may be found by the following Analogy. As 7 is to 22, ſo is 12 to 37, 69. (In the Line of lineal Proportion) extend the Compaſſes from 7 in the upper Line, to 22 in the lower Line; the ſame

extent ſhall reach from 12 to 37, 69, the Circumference required.

Example 2.

The Circumference of a Circle being given, to find the length of the Diameter.

This is the Converſe of the former Example, and the Analogy is the Converſe alſo.

Let the Circumference of a Circle be 37 Inches, 69 Parts, what is the length of the Diameter? As 22 is to 7, ſo is 37, 69 parts to 12 Inches, the Diameter ſought.

Extend the Compaſſes from 22 to 7, in the Scale of Lineal Proportion; the ſame Extent will reach from 37, 69, to the Diameter required.

Example 3.

The Diameter of a Circle being given, to find the Area or Superficial Content thereof.

Let the Diameter of a Circle be 15 Inches, extend the Compaſſes (upon the Scale of Quadratick Proportion) from 1 in the lower Line, to 15 in the upper Line; the ſame extent ſhall reach always from 78, 54, to 176, 25, on the ſame Line, which is the Area of that Circle.

CHAP.

CHAP. XI.

Of Spherical Bodies, ſuch as Globes or Bullets.

Example 1.

THE Circumference of a Globe or Bullet being 28 Inches, 28, parts, to find Diameter.

The ANALOGY.

As 22 is to 7, ſo is 28, 28, the Circumference, to 9 Inches the Diameter.

Extend the Compaſſes from 22 to 7, (on the Scale of Cubical prportions in the lower Line) the ſame Extent will reach from 28, 28, the Circumference, to 9 Inches, the Diameter of the Bullet ſought.

Example 2.

The Diameter of a Shot being given 9 Inches, and its Circumference is 28 Inches, 28 parts: how many ſquare Inches is there in the Superficies of that Bullet?

ANALOGY.

As 1 is to 9 Inches, ſo is 28, 28, the Circumference to 254 Inches 5 parts, the ſuperficial Inches in that Bullet.

Extend the Compaſſes from 1 to 9, (in the lower Line of the Scale of Cubical Proportion) the ſame extent ſhall reach from 28, 28, the Circumference to 254 Inches, 5 parts, the ſuperficial Inches of that Bullet.

Example 3.

The Diameter of a Bullet being 9 Inches; how many Cubical Inches are therein contained?

The ANALOGY.

I. As 1 is to 9 the Diameter, ſo is 9 to a 4*th* Number, and that 4*th* Number to 729 the Cube of the Diameter.

II. As

II. As 9 the Diameter is to 729, its Cube, ſo is 11 to 891 Cubical Inches in that Bullet.

Extend the Compaſſes from 1 to 9 in the Cubical-Scale, that extent will reach to 81, and from 81 to 729 the Cube of the Diameter; then extend the Compaſſes from 9 the Diameter to 729 its Cube, that extent will reach from 11 to 891 Inches, the ſolid Content of the Bullet.

The Deſcription of the Sea-Gunners RULE, *being the Epitome of the Art of Gunnery.*

WHich takes the Convex Diameter of any Shot, the Concave Diameter of the Bore of any Gun, from the Baſe to the Cannon-Royal, on which is inſerted a Line of Numbers for the ready working of any Queſtion in Gunnery.

As alſo ſeveral Lines, ſhewing the Weight and Diameter of any Shot, with the weight of Powder and Shot for any Piece of Ordnance,

nance, the Weight of the Piece, the Length and Breadth of the Ladle, and ſeveral other uſeful matters, as a Line of Chords, a Line of Rhumbs, Leagues and Longitude, (ſuppoſing that every Sea-Gunner is alſo a Navigator;) there is alſo a Circle that taketh any Angle, and will alſo ſhew the Degrees of Mounture of any Piece of Ordnance.

The Deſcription of the Sea-Gunners Rule.

The Rule is a Foot in Length when open; on the Edg is a Line of Inches for the Meaſuring any thing neceſſary to be Meaſured, and may be of any other Length at pleaſure.

Through the Head goeth a Braſs Semicircle fixed to the ſtanding part of the Rule, on which are cut the Diviſions that give the Diameter of a Shot, whoſe Inches are ſhewed by the inſide of the moveable leg of the Rule.

And the Concave Diameter of a Gun is cut upon the Braſs Semicircle by the outſide of the moveable Leg.

There

There is also a Circle of Degrees upon the outward Limb or Edg of the Semicircle, which is to give the Quantity of any Angle cut by the inside of the Moveable Leg of the Rule; by which you may observe the quantity of any Angle to give the Degree of Mounture, with the help of a Plummet that is to hang upon the movable Leg of the Rule.

The Uses follow.

A Deſcription of one ſide of the Rule.

On one ſide of the Rule is placed a Line of Inches, abutting againſt another Line, which ſhews the weight of Iron-ſhot.

And on the ſame ſide is placed a Line of Numbers for the anſwering any Queſtion in Gunnery, with the help of a pair of Compaſſes.

A Deſcription of the other ſide of the Rule.

There are ſeveral Lines on this ſide which ſhew,

The Names of the Guns.
The Weight of Powder.
The Weight of Shot fit for each Gun.
The Length of the Ladle for each Piece.
The Breadth of the Ladle.
The Weight of each ſort of Guns.

Upon the ſame ſide is alſo plac'd the Lines of the plain Scale as,

The Line of Leagues.
The Line of Rhumbs.
The Line of Longitude.
And the Line of Chords.

All

All which is for the Accommodation of the Sea-Gunner, who is alſo a Mariner as well as Gunner.

In the inſide of the Rule there lies two Braſs Legs, which being taken out and opened as far as they will open, the two Points will do the Office of a pair of Calabers.

To take the Diameter of a Shot, cut by the inſide of the moveable Leg upon the edge of the Braſs Semicircle. The Uſes follow.

Uſe 1.

To find the Concave Diameter of the Mouth of any Piece of Ordnance.

This is performed by the two outer Corners of the Rule, being put to the inſide of the Concavity of any Gun, and open the Rule as wide as it will permit, then on the Braſs Semicircle will be cut (by the outer edge of the Rule) the Diameter of the Concavity of the ſaid Piece.

Uſe

Use 2.

To find the Diameter of a Shot.

To perform this you must open the Brass Legs in the inside of the Rule, to their utmost Extent, then open the Points of them to the Diameter of the Shot, and the quantity of Inches and Parts will be cut upon the Semicircle, by the inside of the Leg.

Use 3.

To find the quantity of an Angle, or to find the degree of Mounture of any Piece of Ordnance.

To find the quantity of any Angle upon the Legs of the Rule to any Angle required, and the inside of the moveable Leg will cut the quantity of the Angle upon the Brass Semicircle.

To find and to set the degree of Mounture of a Piece of Ordnance.

You must hang a Threed and Plummet upon the moveable Leg, and put the fixed Leg

Leg into the Muzzle of the Piece, and open the moveable Leg until the Plummet falls perpendicular upon the Line, upon which the Pin is fixed (upon which the Plummet is hang'd) and on the edge of the Braſs Semicircle, will be cut the Angle of the degree of Mounture by the inſide of the moveable Leg.

Uſe 4.

The Uſes of that ſide of the Rule, upon which the Line of Numbers is placed.

On this ſide is placed a Line of Numbers for the ready operation of any Queſtion in Gunnery, with the help of a pair of Compaſſes. The manner of working on the Line of Numbers is ſhewn in the uſe of the Proportional Scale, in this Treatiſe, to which I refer you.

On this ſide of the Rule is plac'd a Line of Inches, on which may be found the Diameter of any Shot: And upon the Line adjoyning to it is ſhewn the Weight of any Shot whoſe Diameter is given.

Ex-

Example 1.

A Shot of four Inches Diameter the Weight is required.

Seek 4 in the Line of Inches (upon this flat ſide) and juſt againſt it you will find 9, which ſhews that a Shot of four Inches Diameter weighs nine Pounds.

Example 2.

A Shot of eight Inches Diameter the Weight is required.

Seek for 8 on the Line of Inches (on the flat ſide) and right againſt it (on the adjoyning Line) you will find 72 which is the Weight of the Shot that is eight Inches Diameter.

Uſe 5.

The Uſe of the other ſide of the Rule.

On this ſide of the Rule are ſix Lines,

The Firſt ſhews the Names of the Pieces, expreſt by the ſeveral Names as, F for

Faulcon,

Faulcon, M for Minion, S for Saker, *&c.*

The Second, the Weight of Powder.

The Third, the Weight of Shot.

The Fourth, the Length of the Ladle.

The Fifth, the Breadth of the Ladle.

The Sixth, the Weight of the Piece.

One Example will ſhew their ſeveral uſes, which ſhall be the Minion, which you will find upon the Line with the Letter M, where under that Line you will find 3 which is, three Pound of Powder for Service, and 4 under that, which is four Pound, the Weight of the Shot.

And 15 in the next Line under that, which ſhews that the Length of the Ladle is fifteen Inches, and in the next Line under that you find 6, which is ſix Inches, the Breadth of the Ladle; and in the laſt Line under 6 you will find 1100, the Weight of the Piece.

On this ſide are plac'd all the Lines of the Plain Scale, the Uſes of which I ſhall not handle in this place, but refer you to my Book of Practical Navigation, where the uſe of every one of them is ſhewn at large.

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